PROCEEDINGS

EPA SCIENCE FORUM 2003:
PARTNERING TO PROTECT HUMAN HEALTH AND THE ENVIRONMENT

May 6-8, 2003

United States Environmental Protection Agency
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Acronyms

ACAT	Alaska Community Action on Toxics
ACC	American Chemistry Council
AOC	Assimable Organic Carbon
APR	air purifying respirator
AQI	air quality index
ASPECT	Airborne Spectral Photographic Environmental Collection Technology
ATSDR	Agency for Toxic Substances and Disease Registry
BDOC	Biodegradable Dissemblic Organic Carbon
CABW	California Aquatic Bioassessment Workgroup
CBEN	Center for Biological and Environmental Nanotechnology
CDC	Centers for Disease Control and Prevention
CHPPM	Center for Health Promotion and Prevention Medicine
CWA	Clean Water Act
DENR	Department of Environment and Natural Resources
DEP	Department of Environmental Protection
DHHS	Department of Health and Human Services
DHS	Department of Homeland Security
DNA	deoxyribonucleic acid
DNR	Department of Natural Resources
DOD	Department of Defense
DOE	Department of Energy

Acronyms (continued)

DOJ	Department of Justice
DOT	Department of Transportation
ECBC	Edgewood Chemical and Biological Center
ECC	Environmental Clearance Committee
EDC	endocrine disrupting chemical
EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency
ETV	Environmental Technology Verification
FBI	Federal Bureau of Investigation
FEMA	Federal Emergency Management Agency
FIELDS	Field Environmental Decision Support
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
GIS	geographic information system
GLNPO	Great Lakes National Program Office
GPRA	Government Performance and Results Act
GPS	global positioning system
GSA	General Services Administration
HEPA	high efficiency particulate air
HCGI	highly credible gastrointestinal illness
HIV	human immunodeficiency virus
HVAC	heating, ventilation, and air conditioning

Acronyms (continued)

IBI	Index of Biological Integrity
IRIS	Integrated Risk Information System
JSAWM	Joint Service Agent Water Monitor
LANL	Los Alamos National Laboratory
MAC	Mycobacterium Avium Complex
MCL	maximum contaminant level
MCLG	maximum contaminant level goal
MDEQ	Michigan Department of Environmental Quality
Med-Fly	Mediterranean fruit fly
MESB	Michigan Environmental Science Board
MOUs	Memoranda of Understanding
NASA	National Aeronautics and Space Administration
NCEA	National Center for Environmental Assessment
NCER	National Center for Environmental Research
NEIC	National Enforcement Investigation Center
NERL	National Environmental Research Laboratory
NHEERL	National Health and Environmental Effects Research Laboratory
NHSRC	National Homeland Security Research Center
NIEHS	National Institute for Environmental Health Sciences
NIOSH	National Institute for Occupational Safety and Health
NNI	National Nanotechnology Initiative

Acronyms (continued)

NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NRMRL	National Risk Management Research Laboratory
NSF	National Science Foundation
OAQPS	Office of Air Quality, Planning, and Standards
OPP	Office of Pesticide Programs
OPPTS	Office of Prevention, Pesticides, and Toxic Substances
ORD	Office of Research and Development
OSC	On-Scene Coordinator
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OWOW	Office of Wetlands, Oceans, and Watersheds
PAH	polycyclic aromatic hydrocarbons
PBT	persistent, bioaccumulative, and toxic
PCB	polychlorinated biphenyl
PLA	polylactides
PM	particulate matter
PPE	personal protective equipment
PVC	polyvinyl chloride
QA	quality assurance
QA/QC	quality assurance/quality control

Acronyms (continued)

QSAR	quantitative structure-activity relationship
ReVA	Regional Vulnerability Assessment
RNA	ribonucleic acid
SBIR	Small Business Innovation Research
SCCWRP	Southern California Coastal Water Research Program
SCECAP	South Carolina Estuarine and Coastal Assessment Program
SDWA	Safe Drinking Water Act
SEQL	Sustainable Environment for Quality of Life
SIP	State Implementation Plan
SMCL	secondary maximum contaminant level
SNL	Sandia National Laboratories
SSC	Science Support Coordinator
STAR	Science to Achieve Results
TIO	Technology Innovation Office
TRC	Toxicogenomics Research Consortium
TRI	Toxics Release Inventory
TSCA	Toxic Substances Control Act
USCG	United States Coast Guard
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WTC	World Trade Center

Executive Summary

The Environmental Protection Agency (EPA) presented the *2003 Science Forum: Partnering to Protect Human Health and the Environment* on Monday, May 5, through Wednesday, May 7, 2003, in Washington, DC to kick off May 2003 as "EPA Science Month." This *Science Forum* highlighted EPA's scientific accomplishments, showcased EPA's commitment to quality science, and demonstrated, through examples, the use of science in decisionmaking and policymaking. The *Science Forum* also provided an opportunity for dialogue and interaction among EPA scientists, clients, stakeholders, and colleagues with over 1,100 attendees at this event, including EPA program, research, and regional staff; members of other Federal agencies; the scientific community; and the public.

The *Science Forum* consisted of a full day plenary session with keynote and plenary speakers and four two-day breakout sessions. Each breakout session examined a theme area—homeland security, moving science into action, year of water, and emerging technologies. The *Science Forum* included 189 posters on current EPA research activities and speaker-specific topics, EPA scientists/engineers present to discuss their research efforts, 16 exhibits of EPA scientific and educational programs, and an awards ceremony for scientific accomplishment.

Plenary Session

The purpose of this session was to provide keynote addresses on the role and value of science and partnerships to support environmental decisionmaking and policymaking, plenary addresses on each of the four topic areas (homeland security, moving science into action, year of water, and emerging technologies), and to introduce the newly-created EPA Office of Homeland Security and National Homeland Security Research Center.

Keynote Addresses. EPA Administrator Christie Todd Whitman opened the *Science Forum* with a perspective on the role of sound science and research in public policy as well as an overview of several EPA research program initiatives such as personnel retention, collaboration with other agencies and organizations, and communicating research results and directions externally. EPA Science Advisor and Assistant Administrator for the Office of Research and Development (ORD), Dr. Paul Gilman, provided highlights of numerous science-related initiatives to address the science needs of EPA as well as the quality of the scientific products. The Regional Administrator for EPA Region 4, Mr. Jimmy Palmer, presented examples illustrating the regional perspective of the EPA's science assets and future scientific needs. Chairman of the White House Council on Environmental Quality, Mr. James Connaughton, discussed overarching science needs and issues facing Federal agencies and the United States government internally and internationally. Director of the Office of Science Policy, Dr. Kevin Teichman, provided an overview of the three-day *Science Forum*.

Plenary Addresses. Director for the Biological and Chemical Porfolio, Dr. John Vitko, provided an overview of the new Department of Homeland Security, identified key initiatives in the biological threat area, and discussed current activities and research initiatives. Secretary of the North Carolina Department of Environment and Natural Resources, Mr. William Ross, Jr.,

discussed the Federal/state partnership and provided examples illustrating how the relationship between North Carolina and EPA are moving science forward in ways that contribute to the environment and human health. Director of the Haudenosaunee Environmental Task Force, Mr. James Ransom, discussed how cultural issues affect science and provided an understanding of the role of traditional knowledge in conjunction with Western science in problem solving. Marine Biologist and Explorer-in-Residence with the National Geographic Society, Dr. Sylvia Earle, discussed the importance of scientific exploration and its role in understanding water, the environment, and human impacts. Director of the Foresight and Governance Project with the Woodrow Wilson International Center for Scholars, Mr. David Rejeski, discussed the current technology revolution and the changes in thinking, approaches, and organizations necessary to address the environmental challenges posed by these emerging technologies.

National Homeland Security Research Center (NHSRC) and Office of Homeland Security. EPA Deputy Administrator, Ms. Linda Fisher, discussed the newly-created NHSRC and its role in supporting EPA responsibilities for homeland security, including water infrastructure protection, safe buildings, rapid risk assessment, and incident response. The Director of the EPA Office of Homeland Security, Ms. Mary Kruger, discussed the role and mission of this new Office both within and external to the Agency.

Homeland Security

This two-day session focused on Homeland Security efforts, specifically response and remediation efforts, threat detection, and incident preparedness. A key theme in these presentations is that interagency collaborations are essential to research programs, successful implementation of security measures, and response and remediation activities.

Anthrax: Response and Research. Dr. Lee Hofmann, with the Office of Solid Waste and Emergency Response (OSWER), led this session addressing lessons learned in responding to the anthrax attacks and new EPA research initiatives in support of homeland security. Mr. Thomas Voltaggio, Deputy Regional Administrator for EPA Region 3, discussed the response and remediation actions taken at the Hart Senate Office Building to address the anthrax contamination. Mr. Timothy Oppelt, Director of NHSRC, discussed the founding of the Homeland Security Research Program and the direction of the Program's current research. Dr. Chris Weis, with the National Enforcement Investigation Center, discussed the importance of science support and coordination in environmental emergency situations, and the practical safety and risk assessment challenges encountered by On-Scene Coordinators (OSC).

Anthrax: Detection, Sampling, and Analysis. Dr. Hofmann, with OSWER, led this session examining sampling methods, protocols, and challenges encountered in responding to the anthrax attacks. Captain Kenneth Martinez, with the National Institute for Occupational Safety and Health (NIOSH), discussed the strategies and procedures involved with the decontamination of the Hart Senate Building. Mr. Mark Durno, EPA Region 5, discussed details of the sampling activities at the Hart Senate Building.

Anthrax: Fumigation and Re-Occupancy. Ms. Anna Treinies, with OSWER, led this session reviewing lessons learned regarding fumigant selection, remediation activities, and developing clearance determinations to re-occupy public spaces contaminated by anthrax. Dr. Dorothy

Clark, Chief Scientist for Bioterrorism Issues in OSWER, discussed the remediation of multiple sites as a result of the anthrax mail attacks. Mr. Matt Gillen, a Senior Scientist with NIOSH, and Mr. Jack Kelly, with EPA Region 3, jointly discussed post-remediation re-occupancy focusing on the organizational, scientific, and communication issues related to building clearance for re-occupancy.

Anthrax: Decontamination Technologies. Mr. Marty Powell, with EPA Region 3, led this session addressing the identification and evaluation of chemicals for use in the treatment of anthrax contamination. Mr. Jeff Kempter, Senior Advisor to the Office of Pesticide Programs (OPP), discussed the crisis exemption for pesticides and the challenges involved with cleanup efforts at anthrax sites. Mr. Jeff Heimerman, with the OSWER Technical Innovation Office, discussed the challenges faced in evaluating emerging anthrax decontamination technology. Ms. Rebecca Schultheiss, with the EPA Environmental Science Center, discussed the duties and capabilities of this laboratory as they relate to the evaluation of decontamination chemicals. Dr. Stephen Tomasino, also with the EPA Environmental Science Center, discussed the complex nature of determining the effectiveness of anti-microbial chemicals, the EPA role in strategy development and advancement of the science, and a research plan for this scientific area.

Building Partnerships Towards Homeland Security. Mr. Craig Mattheson, with the EPA Chemical Emergency Preparedness Office, led this session examining critical infrastructure protection and homeland security, and the interconnectivity of these industries/sectors. Mr. Marty Durbin, Security Team Leader for the American Chemistry Council, discussed security measures and communications tools for consideration in the development of a security plan for a chemical facility. Mr. Paul Bennett, Director of Emergency Management at New York City Department of Environmental Protection, discussed issues related to the response of water utilities in the event of an attack, including the formation of essential partnerships with other agencies/organizations. Mr. Michael Marcotte, with the District of Columbia Water and Sewer Authority, discussed security measures taken at the Blue Plains Water Treatment Facility and security issues for wastewater collection and treatment. Mr. Gordon Smith, Manager of the Public Safety and Technologies Department at Sandia National Laboratories, discussed the development, design, and evaluation of risk assessments as this process relates to vulnerability assessment. Ms. Janet Pawlukiewicz, Director of the EPA Water Protection Task Force (WPTF), discussed accomplishments and ongoing activities in support of the EPA Homeland Security Strategic Plan. Dr. Nancy Adams, with NHSRC, provided highlights of EPA activities under the Safe Buildings Program to address detection, containment, decontamination, and disposal issues.

BioWatch. Mr. Thomas Coda, the lead for Homeland Security Programs in the Office of Air Quality Planning and Standards (OAQPS), provided an overview of the development, implementation, and capabilities of the Bio-Watch surveillance network. Also discussed were the multi-agency responsibilities in this program to rapidly recognize the releases of biological agents before the on-set of illness.

World Trade Center: Lessons Learned and Personnel Protection and Training. Mr. Larry Reed, with the National Institute for Environmental Health Sciences (NIEHS), presented lessons learned regarding the importance of interagency collaborations in the aftermath of the World Trade Center (WTC) attack. Mr. Joseph Hughes, Jr., with NIEHS, and Mr. Bruce Lippy, with

the National Clearinghouse for Worker Safety and Health Training, discussed the conditions and problems encountered at the WTC site with regard to worker safety and training. Dr. Mark Maddaloni, with EPA Region 2, discussed the physical and chemical challenges encountered by EPA Region 2 in supporting the response actions after the WTC attack. Mr. Sven Rodenbeck, Section Chief for the Superfund Site Assessment Branch with the Agency for Toxic Substances and Disease Registry, described the challenges encountered in conducting sampling at the WTC site and the development of the WTC Exposure Registry. Dr. Claudia Thompson, Program Administrator for the NIEHS Superfund Basic Research Program, discussed WTC-related research activities encompassing exposure, modeling, and health effects. Dr. Alison Geyh, Assistant Professor in the School of Public Health with Johns Hopkins University, discussed partnerships that aided in the evaluation of health effects resulting from exposures during the WTC site cleanup. Mr. Herman Gibb, with the National Center for Environmental Assessment (NCEA), discussed the focus and principle findings of the WTC Assessment Report including lessons learned for future responses.

Preparing for Bioterrorism Threats in Water. Dr. Jafrul Hasan, with the Office of Science and Technology (OST), and Mr. Chris Zarba, with the National Center for Environmental Research (NCER), led this session addressing security and detection technology research as they relate to bioterrorism threats in water. Mr. Jonathan Herrmann, with the NHSRC, provided an overview of the key principles, scope, and approach of the Water Security Research and Technical Support Program to provide, within three years, appropriate, affordable, reliable, tested, and effective technologies and guidance for preparedness, detection, contamination, decontamination, and risk of chemical/biological attacks on buildings and on water systems. Ms. Grace Robiou, with the EPA WPTF, discussed the role of the WPTF in water infrastructure security and provided highlights of current research projects for agent prioritization, a response protocol for contamination threats to drinking water, and assessment of laboratory capabilities and capacity. Dr. John Ezzell, a Senior Scientist with the United States Army Medical Research Institute of Infectious Diseases, presented an overview of various technologies and approaches used to detect biological threat agents in water. Ms. Janet Jensen, Project Manager with the United States Army Soldier and Biological Chemical Command, discussed the concept and design of the Joint Service Agent Water Monitor program to develop advanced capabilities to detect, identify, and quantify chemical and biological contaminants in source treated and distributed consumer water supplies. Dr. Alan Lindquist, Technical Lead for Detection of Contaminants of Concern in the NHSRC Safe Buildings and Safe Water Programs, discussed the ongoing initiatives and futures plans for developing the necessary approaches and protocols for the detection of biological agents in water.

Moving Science Into Action

This two-day session focused on ongoing projects and activities involving the use and development of environmental models, data management systems, and interactive tools on a national, regional, state, local, and tribal level. This session presented several pilot projects and communication efforts supported by EPA as well as the goals and uses of scientific data to assess environmental conditions and human health risks. Key themes in the presentations are the need to communicate with decisionmakers in government and industry, and the importance of developing partnerships between Federal, state, local, and tribal governments and organizations.

Regional Vulnerability (ReVA) Assessment: Improving Environmental Decisionmaking Through Client Partnerships. Dr. Betsy Smith, with the National Environmental Research Laboratory (NERL), led this session and provided an overview of ReVA as a flexible framework, including a web-based tool and modeling system, promoting partnerships to build, sustain, and improve community planning, while protecting the environment and human health. Dr. Michael O'Connell, President of the Waratah Corporation, demonstrated the features of the ReVA web-based integration tool, and provided example maps and histograms depicting environmental assessment data for use by decisionmakers. Ms. Rebecca Yarbrough, Project Manager with the Centralina Council of Governments, provided highlights of the Sustainable Environment for the Quality of Life Program, a partnership between EPA, state, and local governments to incorporate environmental considerations into local and regional decisionmaking using ReVA tools. Mr. William Jenkins, Director of the Watershed Management and Analysis Division in the Maryland Department of Natural Resources (DNR), discussed the partnership between ORD and Maryland in the use of ReVA to increase the effectiveness and efficiency of watershed enhancement and restoration activities.

Partnership With State and Local Government. Mr. Gilberto Alvarez, with EPA Region 5, led this session presenting ongoing projects that are prime examples of partnerships between EPA, state or regional agencies, and other organizations. Dr. Bruce Herbold, with EPA Region 9, described the studies of water quality, based on the migration of salmon, at the Delta Cross Channel Gate in California. Dr. Linda Rimer, with EPA Region 4, discussed efforts to promote quality of the environment in land use planning and political decisionmaking as well as the threats to the environment and human health resulting from human sprawl and land development. Mr. Keith Harrison, Director of the Office of Special Projects with the Michigan Department of Environmental Quality, provided highlights of efforts by the Michigan Environmental Science Board to protect children's health, including an environmental standards investigation.

Advancing Science Through Environmental Monitoring and Assessment Program (EMAP) Partnerships. Dr. Michael McDonald, Director of EMAP, led this session providing highlights of EMAP and its applications as well as current and future initiatives involving this web-based tool. Dr. Roger Blair, with the National Health and Environmental Effects Research Laboratory (NHEERL), provided an overview of the EMAP and EMAP-West efforts and tools to estimate the current status/trends of selected environmental indicators on a regional basis, seek associations between indicators and stressors, prepare periodic assessments, and to define quantitative biocriteria among other goals. Mr. Karl Hermann, with the EPA Region 8 Ecosystem Protection Program, discussed the EMAP Western Pilot project to produce a regional assessment of the ecological conditions of streams in EPA Region 8, and stakeholder partnerships important to project success. Mr. James Harrington, with the California Department of Fish and Game, discussed collaboration of the EPA and the State of California to develop biocriteria and improve water quality monitoring programs, methods, and protocols. Mr. Jefferson Davis, a Scientist with the Nez Perce Tribe, described the role of EMAP in supporting current conditions of streams within the reservation and using the bioassessment applications to develop water quality standards and criteria, complete a Clean Water Action Section 303(d) listing of impaired areas, and develop maximum daily load values.

In a second session on EMAP, Dr. Kevin Summers, with NHEERL, provided highlights of the National Coastal Assessment Program and initiatives to build the scientific basis as well as the

local, state, and tribal capacity to monitor the status and trends in the condition of the Nation's coastal ecosystems. Dr. Stephen Weisberg, with the Southern California Coastal Water Research Program, discussed how EMAP has supported and influenced the Southern California coastal monitoring programs and current activities to develop cooperative regional monitoring surveys. Dr. Robert Van Dolah, with the South Carolina Department of Natural Resources, provided highlights of the South Carolina Estuarine and Coastal Assessment Program to monitor and report on the conditions of biological habitats, including tidal creeks and open water. Ms. Darvene Adams, the EPA Region 2 Monitoring Coordinator, described EMAP and Regional EMAP objectives in EPA Region 2 to support state monitoring programs and address regional priorities, including an EMAP design for monitoring based on probability, approaches for indicator development, and approaches for water quality standards.

Working with Tribes: Cultural Values and Tribal Lifeways Inform Health Assessments. Mr. Thomas Baugh, with EPA Region 4, led this session providing examples of partnering between tribes and government agencies to maintain healthy environments, acquire new or better data, develop data analysis tools, and to communicate environmental risks and conditions. Ms. Sarah Ryan, with the Big Valley Rancheria, explained the traditions and goals of the reservation to improve pesticide management, community recycling, and communication of diverse environmental and human health effects within their community. Ms. June Gologergen-Martin with the Alaska Community Action on Toxics (ACAT) discussed the ACAT Program and tribal efforts to address environmental health issues prevalent on St. Lawrence Island, including funding, investigation of the nature and extent of contamination resulting from the United States military and other sources, and incorporating their input into decisionmaking efforts of surrounding areas. Mr. Larry Campbell and Ms. Jamie Donatuto, with the Swinomish Indian Tribal Community, presented the issues of contamination of subsistence-harvested shellfish and their project to study the bioaccumulative toxics in shellfish on the Swinomish reservation to address environmental and human health concerns.

Moving Science into Action -- Step One: Get the Data! Ms. Pamela Russell and Mr. Mike Flynn, with the Office of Environmental Information (OEI), led this session presenting the acquisition and analysis of data critical to completing environmental and human health risk assessments as well as current initiatives and partnerships. Ms. Gail Froiman, with OEI, provided an overview of the EPA Toxics Release Inventory (TRI) program and discussed uses of the data to support communication and decisionmaking efforts for government agencies, community organizations, industry, and international organizations. Dr. Ron Klauda, with the Maryland DNR, and Mr. Keith Van Ness, with the Montgomery County Department of Environmental Protection, presented highlights of an EPA, Maryland, and Montgomery County partnerships using TRI data to improve stream monitoring and watershed assessment. Dr. Jonathan Kennan, with the United States Geological Survey, discussed ongoing projects with OEI to address adverse effects of urbanization; evaluate the relations among land use, extant fish species composition, and stream water quality; and determine if there are significant relations between fish assemblage structure and environmental quality across a disturbance gradient. Dr. William P. Smith, with OEI, discussed the use of TRI data in creating dynamic choropleth maps to visually depict trends in human health and environmental conditions.

Emerging Innovations in Regional Ecosystem Protection. Mr. Doug Norton, with the Office of Water, provided highlights of an EPA workshop on critical ecosystem assessment and the use of

geospatial modeling to support such assessments. Dr. Mary White, with EPA Region 5, discussed the use of geospatial analysis to characterize ecosystems, including the composite assessment of diversity, sustainability, and land cover rarity factors. Ms. Brenda Groskinsky, with EPA Region 7, described synoptic modeling as a method to rank and prioritize wetland ecosystems to support decisionmaking on resource allocation and wetland protection. Dr. John Richardson, with EPA Region 4, provided highlights of the Southeastern Ecological Framework's GeoBook project that uses geographic information system (GIS) modeling to determine appropriate ways to study and protect ecosystems as well as to support decisionmakers in identifying issues important to surrounding communities. Mr. Tom DeMoss, with the Canaan Valley Institute, described the Mid-Atlantic Highlands Program for collaborative monitoring, research, management, and restoration activities within the Mid-Atlantic Highlands.

Site Characterization and Decision Analysis of Contaminated Sediment. Dr. John Bing-Canar, with EPA Region 5, led this session that illustrated new tools and techniques supporting scientific analysis and decisionmaking at a contaminated sediments site. Mr. Brian Cooper, with EPA Region 5, provided an overview of a collaborative project between EPA, academia, and the National Oceanic and Atmospheric Administration to apply GIS tools for three-dimensional visualization, characterization, and decision analysis of contaminated sediments. Dr. John Kern, with Kern Statistical Services, Inc., discussed sampling design and procedures for the same contaminated sediments study. Dr. Bing-Canar discussed exploratory data analysis and other spatial estimation methods used to determine chemical mass and volume at the contaminated sediments study site. Mr. Charles Roth presented the methods used for spatial estimation that result in defendable, repeatable, and accurate data, and the creation of a risk analysis tool to support decisionmaking.

Year of Water—30 Years of Progress Through Partnerships

This two-day session focused on human impacts on water systems, ecological and human health implications of impaired systems, tools and techniques for improved tracking and monitoring of water system degradation, improvement in overall water quality, the relationship between drinking water and waterborne disease, and specific challenges involving invasive species and coral reef management. All presentations highlighted EPA partnerships with state, local, and tribal governments as well as the role of volunteer monitoring in addressing water issues. Key themes in all of the discussions were the need for diverse bioindicators, increased understanding of water habitat stressors, techniques for information sharing, and challenges in reversing impairment that has already occurred.

Waterborne Disease in the United States. Dr. Fred Hauchman, with NHEERL, led this session on waterborne disease trends and factors affecting microbiological contamination of drinking water. Dr. Rebecca Calderon, Chief of the Epidemiology and Biomarkers Branch at NHEERL, discussed the challenges in detecting and determining the causes of waterborne diseases and the related research conducted by EPA and the Centers for Disease Control and Prevention (CDC). Dr. Jack Colford, Associate Professor of Epidemiology at the University of California, Berkeley, presented the results of a study of drinking water intervention in human immunodeficiency virus (HIV)-sensitive populations and the frequency of gastrointestinal illnesses as a result of impaired drinking water these populations. Dr. Mark LeChevallier, Director of Research at American

Water, discussed monitoring and control techniques to maintain the biological integrity of drinking water during distribution to users.

Mississippi River Basin Hypoxia. A panelist discussion provided an overview of the complex hypoxia issue involving the Mississippi River basin and the northern Gulf of Mexico. Mr. Lee Mulkey, Associate Director for Ecology at the National Risk Management Research Laboratory (NRMRL), discussed the relationship of nonpoint source nutrient loading and hypoxia in the Gulf of Mexico as well as current interest in free market solutions to address this area of concern. Dr. Mary Belefski, with the Office of Prevention, Pesticides, and Toxic Substances, provided highlights of six reports examining the science and economic aspects of the hypoxia issue, and research involved in developing analysis tools and potential resolutions. Ms. Katie Flahive, with the Office of Wetlands, Oceans, and Watersheds (OWOW), presented an overview of an Action Plan to reduce, mitigate, and control hypoxia in the northern Gulf of Mexico as well as partnerships among Federal agencies, states, and tribes to implement Action Plan goals to reduce nutrient loading and reduce the size of the hypoxic zone.

The Millennium Challenge: EPA's Response to Invasive Species. Mr. Michael Slimak, Associate Director for Ecology at NCEA, and Ms. Marilyn Katz, with OWOW, led this session and provided background on the impacts and economic cost associated with invasive species and efforts underway to combat this complicated issue. Assistant Administrator of the Office of Water, Mr. G. Tracy Mehan III, provided an overview of the extent of the invasive species issue, and key initiatives to control the introduction. Dr. Richard Everett, with the United States Coast Guard, presented highlights of research related to invasive species, and the use of new technologies, regulations, and best management practices to actively combat invasive species entry routes. Ms. Kathy Hurld, with OWOW, presented the international perspective of invasive species and the progress toward the development of an international ballast water treaty. Dr. Marc Tuchman, Team Leader for both the Sediment Assessment and Remediation Team and the Invasive Species Team at the Great Lakes National Program Office, discussed the development and introduction of an electrical barrier to prevent the spread of Asian Carp into the Great Lakes. Mr. Daniel Rosenblatt, Team Leader for the Emergency Response Team at OPP, discussed how Federal pesticide laws and insect control programs help to control the spread of invasive species and health considerations related to pesticide use. Ms. Jacqueline Savitz, Pollution Campaign Director and Senior Scientist for Oceana, discussed the importance of preventing the introduction of invasive species as a primary management control and the need for careful consideration and precaution before using toxic chemicals for invasive species control as evidenced by unintended consequences of past chemical use.

Social Science and Resistance to Water Fluoridation. Mr. Bill Hirzy, with the National Treasury Employees Union, and Ms. Roberta Baskin, a Senior Reporter, introduced this session and the intent to host a debate about the science and national policy of water fluoridation, which is considered a controversial issue. Dr. Ed Ohanian, Director of the Health and Ecological Criteria Division in the Office of Science Technology, presented an overview of drinking water regulations and the health benefits of fluoride addition as well as current initiatives to review new health effects and exposure data. Dr. Paul Connett, a professor at St. Lawrence University, presented research, data, and other information in support of a counter viewpoint on the necessity for a national water fluoridation policy and the health consequences of fluoride ingestion.

Development of Biological Indices for Coral Ecosystem Assessments. Mr. Kennard Potts, with OWOW, led this session and introduced the goals for developing indicators for coral reef health, the EPA role and partnerships in coral reef management, and the current research initiatives. Dr. Jordan West, with NCEA, discussed the importance of coral reefs, local and global stressors affecting reefs, and efforts of the United States Coral Reef Task Force to provide interagency collaboration on the issue of coral bleaching. Dr. Richard Zepp, Senior Research Scientist with NERL, discussed the linkage between increasing irradiance (light) and increasing water temperature as well as El Nino effects and coral reef decline. Mr. William Swietlik, Program Manager for the Biocriteria Program in the OST, discussed the utility of biocriteria to assess coral reefs and the benefits of incorporating such biocriteria into water quality standards. Dr. Steven Jameson, President of Coral Seas, Inc., discussed the development and use of an Index of Biological Integrity (IBI) as a more accurate method to monitor and assess coral reefs drawing on the success of IBIs in freshwater environments and the transferability of IBIs as indicators to marine environments.

The Impacts of Urban Drainage Design on Aquatic Ecosystems in the United States. Mr. Jamal Kadri, with the Office of Water, led this session on the use of Smart Growth tools and initiatives for watershed protection and management, and described the EPA role and interest in urban drainage design. Ms. Diane Regas, with OWOW, discussed Smart Growth principles, their use in addressing major land development and other threats to estuaries and watersheds, and emphasize the need for EPA to continue to foster partnerships with local governments in this endeavor. Ms. Hye Yeong Kwan, Executive Director for the Center for Water Protection, discussed the use of impervious cover as an indicator for watershed quality and a roundtable approach to introduce Smart Growth concepts to community leaders seeking to protect their watersheds.

Innovative Monitoring Techniques. Ms. Susan Holdsworth, with OWOW, led this session and discussed the importance of developing innovative monitoring techniques to fill gaps in monitoring that exist for the majority of the waters of the United States that in turn challenges our ability to understand which waters are impaired or in danger of being impaired. Ms. Susan Jackson, with the Biocriteria Program, discussed the use of biological indicators to assess water quality, demonstrated the added value of their use, and noted partnerships important to addressing important monitoring questions. Mr. Barry Burgan, a Senior Marine Scientist in OWOW, presented probabilistic monitoring approaches as a cost-effective, innovative technique to assess wetland and estuarine quality. Ms. Denise Wardrup, Assistant Director of the Penn State Cooperative Wetlands Center, discussed the use of GIS, land use, and landscape information to conduct a variety of assessments of watershed condition at the desktop level prior to conducting onsite surveys.

Volunteer Monitoring—Ten Years of Progress. Mr. Joe Hall, with OWOW, led this session addressing diverse examples of volunteer monitoring efforts and their contribution to environmental programs. Ms. Alice Mayio, with OWOW, provided an overview of volunteer monitoring in the past and present, EPA sponsorship of volunteer monitoring, partnerships, and the applicability of volunteer data. Ms. Kathleen Kutschenreuter, with OWOW, discussed how volunteer monitoring relates to wetlands protection and quality data collection drawing on examples of successful volunteer wetlands cooperative projects and partnerships. Mr. Joe Hall, with OWOW, described how volunteers support coastal and estuarine monitoring initiatives with

examples from the National Estuary Program. Ms. Mayio concluded the session with a review of the future challenges and opportunities for volunteer monitoring programs.

Emerging Technologies

This two-day session focused on the application, use, and research directions for diverse emerging technologies, including computational toxicology, genomics, advanced information technology for simulation and modeling, biotechnology, and nanotechnology. Key themes in all of the discussions were the fast pace of development and introduction of these technologies; the increasing ability to understand toxicity, chemical reactions, and other mechanisms at the molecular and genetic levels; the great promise for more environmentally-benign manufacturing; the need for interdisciplinary and interagency collaboration on research programs supporting the development of these emerging technologies; and the need to understand the effects and future implications of these new technologies on human health and the environment to support decisionmaking and regulation.

Applying Computational Toxicology to Solving Environmental Problems. Dr. William Farland, Acting Assistant Administrator for Science and Research and Development for ORD, led this session, defined computational toxicology, and noted potential applications to reduce animal testing for understanding biology and risk. Dr. Donna Mendrick, with Gene Logic, Inc., discussed current efforts to build and apply a toxicogenomic database to predict pharmaceutical and chemical effects as well as the mechanisms of toxicity. Dr. Lawrence Reiter, Director of NHEERL, provided an overview of computational toxicology research at EPA and the use of a conceptual or science framework for guiding research. Dr. William Welsh, with the Robert Wood Johnson Medical School and the University of Medicine and Dentistry of New Jersey, discussed the development and application of computation tools useful to risk assessment and regulatory control with emphasis on quantitative structure-activity relationship models. Dr. Douglas Wolfe, with NHEERL, presented applications of computational toxicology and genomics to risk assessment for drinking water. Dr. David Lattier, with NERL, discussed the use of computational toxicology in conjunction with genomics, proteomics, and metabonomics to assess the path from stressor to exposure to effect in aquatic ecosystems. Mr. Joseph Merenda, Jr., with the Office of Science Coordination and Policy, provided the program office perspective on the use of structure-activity tools, the types of tools in use, and gaps or needs to fill. Dr. Bennett Van Houten, Chief of the Program Analysis Branch at NIEHS, provided highlights of the recently established National Center for Toxicogenomics and its research initiatives.

Innovation to Advance the Detection of Threats and Optimize Environmental Decisionmaking. Dr. Gary Foley with NERL led this session and discussed the role of advanced information technology and modeling to gather, integrate, and interpret environmental data to improve risk assessment and develop decision tools to support multi-stressor regional decisionmaking. Dr. David Nelson, with the White House National Coordination Office for Information Technology Research and Development, provided highlights of the Federal Networking Information Technology Research and Development Program including examples of information technology applications to environmental issues. Ms. Ramona Trovato, with OEI, discussed EPA use of information technology to acquire and manage incoming data and the use of such data to make sound decisions. Mr. David Williams, with ORD, and Mr. Jim Szykman,

with OAQPS, addressed the use of satellite-based remote sensing systems to evaluate human and ecosystem health issues. Dr. Mark Thomas, with EPA Region 7, presented an airplane-based technology in use by EPA to assist with emergency response to incidents involving chemical releases. Dr. Steven Perry, with NERL, discussed the use of computer imaging and wind tunnel testing to characterize the temporal and spatial patterns of contaminant movement and deposition from the WTC collapse. Mr. Timothy Hanley, with the Office of Air and Radiation, addressed the use of real-time monitoring data to communicate air quality conditions to the public.

Applying Biotechnology to Achieve Sustainable Environmental Systems. Dr. Hugh McKinnon, Director of the National Risk Management Research Laboratory, led this session on diverse types and applications of biotechnology. Dr. Barry Marrs, with the Fraunhofer Center for Molecular Biotechnology, discussed the use and implications of molecular farming to replace traditional chemical manufacturing with emphasis on the use of enzymes as catalysts. Dr. Lawrence Reiter, Director of NHEERL, presented highlights of the EPA biotechnology research program to improve understanding of the health and environmental effects from agricultural biotechnology products and to support the EPA mandate to regulate such products. Dr. Janet Anderson, with OPP, discussed the role of science in the regulation of biotechnology. Dr. Robert Frederick, with NCEA, provided an overview of monitoring strategies to support risk assessment and decisionmaking with regard to bioengineered crops. Dr. John Glaser, with NRMRL, presented potential applications of satellite-based remote sensing systems to support compliance monitoring and evaluation of the development of insect resistance in bioengineered crops. Dr. John Dorgan, with the Colorado School of Mines, discussed the environmentally-friendly production and use of biopolymers to create biodegradable plastics and other products. Dr. Deborah Hamernik, with the United States Department of Agriculture (USDA), provided highlights of the USDA Biotechnology Risk Assessment Research Grants Program to support multiple Federal agencies in making science-based decisions about the safety of introducing genetically-modified organisms into the environment.

Applying Nanotechnology to Solve Environmental Problems. Dr. Jack Puzak, Acting Director of NCEA, led this session, provided highlights of EPA and other Federal research initiatives for nanotechnology, and identified potential nanotechnology applications and research directions. Dr. Vicki Colvin, with the Center for Biological and Environmental Nanotechnology, discussed current research for the creation of nanomaterials to improve membrane filter performance and to remove specific contaminants from wastewater. Dr. Mike Roco, a Senior Advisor with the National Science Foundation, presented highlights of the National Nanotechnology Initiative, nanotechnology applications, and future research directions. Dr. William Trogler, with the University of California-San Diego, presented recent research results for the production and use of polysiloles as nanotechnology chemical sensors for arsenic and hexavalent chromium. Dr. Wilfred Chen, with the University of California-Riverside, addressed current research results for the production, modification, and use of biopolymers to selectively remove specific heavy metals from wastewater. Dr. Kristen Fichthorn, with Pennsylvania State University, discussed new understandings of molecular dynamics of colloidal nanoparticles derived from simulations and experimental research. Dr. Vicki Grassian, with the University of Iowa, presented techniques to generate zeolite nanoparticles and potential applications of the resulting properties in catalysis and optically transparent films and coatings.

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Section I: Overview

The Environmental Protection Agency (EPA) presented a *Science Forum* at the Ronald Reagan Building and International Trade Center in Washington, DC, on Monday, May 5, through Wednesday, May 7, 2003, to kick off May 2003 as "EPA Science Month." The *EPA 2003 Science Forum: Partnering to Protect Human Health and the Environment* was an opportunity to showcase the activities of EPA and other organizations in key areas of environmental research and to spotlight new initiatives and recent successes. As the second of what is anticipated to be annual event, this *Science Forum* built upon the first ever Agency-wide *Science Forum* held in May 2002, and was co-sponsored by the Office of Research and Development (ORD), the Office of Water, the Office of Solid Waste and Emergency Response (OSWER), and EPA Region 4.

The *Science Forum* highlighted selected high priority topics and EPA's scientific accomplishments, showcased EPA's commitment to quality science, and demonstrated, through examples, how science influences Agency decisions. The Science Forum also provided an opportunity for dialogue and interaction among EPA scientists, partners, clients, stakeholders, and colleagues with over 1,100 attendees at this event. Attendees included EPA program, research, and regional staff; members of other Federal agencies; stakeholders; the scientific community; and interested members of the public. The *Science Forum* included 189 posters addressing current EPA research activities and specific topics addressed by speakers, discussions of research efforts by EPA and external scientists and engineers, and 16 exhibits of EPA scientific and educational programs.

EPA Administrator Christie Todd Whitman opened the first day of the *Science Forum* with a perspective on the role of sound science and research in public policy and provided an overview of several EPA initiatives to maintain and promote the Agency's commitment to quality science. Other keynote speakers provided highlights of ongoing initiatives to address the science needs of EPA and the quality of its scientific products, the regional perspective of EPA's science assets and future scientific needs, and overarching science needs and issues facing Federal agencies and the United States government internally and internationally. Subsequent plenary presentations addressed each of the four theme areas emphasized in this *Science Forum* as well as EPA's newly created National Research Center for Homeland Security and Office of Homeland Security. At a reception following the keynote and plenary addresses, Level 1 Scientific and Technological Achievement Awards were presented to four EPA personnel in recognition of their high quality research of national significance or impact.

Four two-day breakout sessions each examined a theme area—homeland security, moving science into action, year of water, and emerging technologies. The audience had an opportunity in each session to ask questions of the speakers. Poster sessions followed the plenary session and each breakout session addressing session-specific and related topics. EPA engineers and scientists were available at these poster sessions to provide additional information and to address questions of attendees.

Section II: Plenary Session

Monday and Tuesday, May 5-6, 2003

The purpose of this session on the first day and the beginning of the second day of the meeting was to provide keynote addresses on the role and value of science and partnerships to support environmental decisionmaking and policymaking, provide plenary addresses on each of the four topic areas (homeland security, moving science into action, year of water, and emerging technologies), and introduce the newly created EPA Office of Homeland Security and National Homeland Security Research Center.

EPA Administrator Christie Todd Whitman opened the *Science Forum* with a perspective on the role of sound science and research in public policy as well as an overview of several EPA research program initiatives. EPA Science Advisor and Assistant Administrator for ORD, Dr. Paul Gilman, provided highlights of ongoing initiatives to address the science needs of EPA as well as the quality of the scientific products. The Regional Administrator for EPA Region 4, Mr. Jimmy Palmer, presented examples illustrating the regional perspective of the EPA's science assets and future scientific needs. Chairman of the White House Council on Environmental Quality, Mr. James Connaughton, discussed overarching science needs and issues facing Federal agencies and the United States government. Director of the Office of Science Policy, Dr. Kevin Teichman, provided an overview of the three-day *Science Forum*.

Director for the Biological and Chemical Countermeasures Portfolio, Dr. John Vitko, provided an overview of the new Department of Homeland Security (DHS), identified key initiatives in the biological threat area, and discussed current activities and research initiatives. Secretary of the North Carolina Department of Environment and Natural Resources (DENR), Mr. William Ross, Jr., discussed the Federal/state partnership and provided examples illustrating how the relationship between North Carolina and EPA is moving science forward in ways that contribute to the environment and human health. Director of the Haudenosaunee Environmental Task Force, Mr. James Ransom, discussed how cultural issues affect science and provided an understanding of the role of traditional knowledge in conjunction with Western science in problem solving. Marine Biologist and Explorer-in-Residence with the National Geographic Society, Dr. Sylvia Earle, discussed the importance of scientific exploration and its role in understanding water, the environment, and human impacts. Director of the Foresight and Governance Project with the Woodrow Wilson International Center for Scholars, Mr. David Rejeski, discussed the current technology revolution and the changes in thinking, approaches, and organization necessary to address the environmental challenges posed by these emerging technologies.

EPA Deputy Administrator, Ms. Linda Fisher, discussed the newly created National Homeland Security Research Center (NHSRC) and its role in supporting EPA responsibilities for homeland security. The Director of the EPA Office of Homeland Security, Ms. Mary Kruger, discussed the role and mission of this new Office.

Opening Remarks

Director of the Office of Science Policy within the Office of Research and Development (ORD), Dr. Kevin Teichman, welcomed all the attendees to this second annual EPA-wide *Science Forum: Partnering to Protect Human Health and the Environment*, and introduced the co-chair of the development committee, Ms. Megan Grogard. Dr. Teichman introduced the keynote addresses for the morning plenary session.

Keynote Addresses

The EPA Administrator, the EPA Science Advisor, and the Regional Administrator for EPA Region 4 provided opening addresses to Science Forum attendees on the role of science at EPA, current initiatives, and future directions. The Chairman of the White House Council on Environmental Quality provided a national and international perspective on how changes in scientific understanding of the environment and natural resources impact government decisionmaking.

EPA Administrator Keynote Address

EPA Administrator Christie Todd Whitman acknowledged the unique opportunities provided by this *Science Forum* to bring the EPA science community together with other partners and to showcase a broad range of cutting-edge research. EPA relies on sound science to understand the environmental problems and the risks they pose to quality of life, identify potential solutions and analyze which will do best, and determine the effectiveness of current programs and public policies to meet the overall goal of cleaner air, purer water, and better protected land. To rely on something this strongly requires the foundation to be strong, and this is a hallmark of EPA science.

Nonetheless, efforts continue to look for ways to strengthen this vital program and to increase the role of science into the decisionmaking all the way through to the final product (e.g., rule, guidance). At the beginning of her tenure, Administrator Whitman established a commission to review the use of science at the Agency and a number of the recommendations have been implemented, including the improvement of resources that determine the quality of EPA science, partnering with external organizations to address important scientific research common to many programs, and enhanced communication and coordination internally and externally.

While EPA attracts some of the best and brightest minds in the United States, efforts continue to retain EPA scientific personnel and to support a strong post-doctoral program to continue their contributions to EPA programs and produce future leaders in science and engineering. Recognizing that recruiting great scientists is not sufficient and their work must be included in regulations and other programs, EPA has increased the number of laboratory engineers and scientists supporting regulatory programs, and holding the regulatory programs to the same scientific standards as in the research programs.

Important scientific work is being conducted outside of the EPA and the United States government that is useful to EPA activities. In addition, no one agency or organization has sufficient resources to conduct all of the research necessary, therefore all interested organizations

benefit from sharing of information as well as resources. Examples of such collaboration include a joint initiative with the American Chemistry Council to understand chemical impacts on children's immune systems, and the Science to Achieve Results (STAR) program that has supported outside agency research by providing more than $700 million through more than 800 grants since 1995—a true example of meaningful investment.

However, having "best in the world science" is of little value if the results are not communicated or do not establish public confidence. Through the leadership of Dr. Paul Gilman, EPA Science Advisor and Assistant Administrator for ORD, EPA is continuing to improve internally the application and use of science, and communicating externally the value and strength of the science. From the Science Policy Coordinating Council, which helps to direct the use of scientific and technical information, to policy decisions and developing the information quality guidelines that set high standards for scientific information, there is a much clearer understanding today in how to use EPA science and what the Agency expects from its science. Multiple initiatives continue to ensure that this understanding is communicated to the outside world and is coordinated across the Agency and its regions, partners, and the public.

Administrator Whitman also noted that this *Science Forum* provides the opportunity to visit exhibits showcasing EPA research efforts, meet with top Agency scientists and engineers, participate in panel discussions on pressing environmental topics, and develop ideas on how to expand both science and partnerships. Administrator Whitman thanked Dr. Gilman and everyone who helped put this *Science Forum* together, and noted the need to continue to rely on the sound science that has led to the achievements thus far in order to address environmental challenges that are more complicated today than those in the past.

EPA Science Advisor and ORD Assistant Administrator Keynote Address

EPA Science Advisor and Assistant Administrator for ORD, Dr. Paul Gilman, provided highlights of ongoing initiatives to address the science needs of the EPA, with titles of EPA scientist awards and publications projected in the background. The number of personnel involved in the regulatory planning process has doubled and the number of different projects that have involved EPA scientists and engineers increased by about 35 percent in the last year. More efforts focus on retaining the core research that provides the tools necessary to identify and address emerging issues. At this time, EPA research is equally split between basic science and problem-driven science, and expectations are that this will be maintained in the future.

Examples of science-related initiatives at EPA include:

- Creation of an inventory of all research activities, involving more than 4,500 entries, anticipated to be publicly available on the Internet in the next year

- Preparation of information quality guidelines drawing on the quality assurance/quality control (QA/QC) program already in effect at EPA and that guides how to do the work well and thoroughly

- Compilation of the first comprehensive list of bio-indicators with assistance from the Council on Environmental Quality, anticipated to be available in the next few months

- Development of a genomics policy to address the implications of a new set of technologies across ORD and the EPA Program Offices as well as tools acceptable to the regulators and the regulated community

- Implementation of research initiatives on asthma and aging

- Enhancement of the Integrated Risk Information System (IRIS) database, a flagship database receiving thousands of queries annually

- Re-invigoration of regulatory environmental modeling, including an inventory of computer models used by the Agency, and working with the National Academies of Science to address a future vision for model use and QA/QC

- Conduct of a cross-agency forum on environmental measurements (including methods, validation processes, and training to disseminate new methods) to ensure development of sound, reliable measurements to support sound and reliable decisionmaking

- Revamping the Government Performance and Results Act (GPRA) process and reducing the goals from 10 to five, with each goal highlighting research and cross-cutting initiatives involving the EPA Programs, Regions, and ORD

- Implementation of homeland security research, an integrated effort of the Offices of Water, Research and Development, and Prevention, Pesticides, and Toxic Substances in conjunction with a vast interagency effort.

Congressional concern for improving QA programs at Federal agencies is also a key issue for EPA. Ten years ago, EPA actively responded to criticism of its peer review process and solicited input on the conduct peer review for scientific and other types of EPA products. As a result of this effort, the number of products undergoing peer review increased from 112 in 1995 to 895 in 2002, of which 450 underwent external peer review, 225 underwent journal peer review for publication, and 75 underwent internal review. An EPA Science Advisory Board member recently testified positively to the House of Representatives on the status and improvements of the EPA peer review program, noting that little more needs to be done.

EPA Region 4 Administrator Keynote Address

The Regional Administrator for EPA Region 4, Mr. Jimmy Palmer, presented the regional perspective of the science assets and future scientific needs. EPA Region 4 is a co-sponsor of this *Science Forum*, and is a lead EPA Region for research and information. Many of the day-to-day regulatory and compliance issues faced in Region 4 cross all of the topic areas addressed in this *Science Forum*.

Mr. Palmer presented a number of examples illustrating the role and use of science in regulatory decisionmaking, how scientific understanding changes over time, the associated implications in regulation, and the importance of science in addressing public concerns. Across all these examples are three common elements: the science, data availability, and the public. These

examples included: (1) the need for legislative change regarding models used for stream flow (that controlled the ability of farmers to remove water to irrigate their fields) given existing drought conditions no longer met the assumptions of the model (i.e., presence of a stable hydrogeologic regime); (2) the provision of multiple, conflicting scientific opinions to residents near a large polychlorinated biphenyl (PCB)-contaminated area resulting in confusion and concern; and (3) the challenges in communicating valid scientific information to distraught families and a concerned public that did not support their assumptions regarding an environmental cause for an asthmatic attack leading to a child's death. The latter two examples demonstrate the desire of the public to hear and give credence to scientific understanding, yet are at risk of others with their own agenda who may not be as dedicated to the integrity of the science.

Examples of emerging technologies within Region 4 included: (1) the use of phytoremediation (trees and bulrushes) to cleanup contaminated groundwater and trap heavy metals from surface water at the Savanna River Site; (2) following up on a contact via a defense contractor to become involved in cutting-edge technology development for measurement of biological agents in surface water as an early warning system for contamination at Oak Ridge National Laboratory; (3) successful collection and transfer of landfill gas to an automobile manufacturing plant for use; and (4) the promise of a plasma technology developed by the Georgia Institute of Technology and a private partner to convert municipal solid waste to glass, which can be ground and reused for paving material, for building material, and to entrain pollutants including radionuclides.

Mr. Palmer noted that the discussions at this *Science Forum* will address both pure and applied science. Mr. Palmer also announced a new initiative from Administrator Whitman to begin a 45-day self-assessment (beginning with EPA Region 4) to identify how to better marshall the Agency's scientific assets to meet the practical needs at the Regional level and to identify the research needs at the Regional level.

White House Council on Environmental Quality Keynote Address

Chairman of the White House Council on Environmental Quality, Mr. James Connaughton, discussed overarching science needs and issues facing Federal agencies as well as the United States government. The past 30 years have seen great advancements in risk assessment and in understanding underlying scientific principles such as uptake and how systems interact. The next 30 years will build on this foundation and associated tools with a key question being how to fit this understanding into a policy framework. Historically, advisory and policymaking personnel often waited to hear the scientific message and were less involved in moving the science forward; with the current need for faster decisionmaking, risk communication is now very important. Eight examples illustrated the role of science, risk assessment, and risk communication in environmental policymaking and decisionmaking.

First, forest management decisions made over 100 years ago, based on the science of the time, resulted in a build up of fuel that now causes very intense fires. This illustrates the need to revisit policy decisions as scientific understanding changes over time. Challenges faced in the current healthy forests initiative include understanding the truly natural condition, how to effectively return to this condition, and the need to interface with scientific input, the Federal

sector with forest management responsibilities, and the contractors who conduct the actual work. This combines understanding of risk assessment, practical field knowledge, and accomplishing projects with scientific basis and merit.

Second, improved understanding of the environmental condition has resulted in a global interest on research into technologies to better support sustainable development, yet the areas of desired emphasis vary. For example, the fundamental needs of developing countries are for energy, agriculture, and water, with expectation of assistance in these areas from the developed countries. The world's first zero pollution, zero green house gas emission, coal-fired power plant will be built in the United States in the next 10 years and this construction will coincide with the next round of investment in developing countries; this represents a future opportunity to transition such a technology. Also, renewed interest in fusion as an energy source is a result of computer advances enabling improved understanding of the risks in development to support better decisionmaking on the timeframe for fusion development.

Third, a very rich debate is currently underway worldwide regarding biotechnology applications for future agricultural practices. Many of these discussions occur at high government levels and with superficial assertions about the science. Future discussions must stay centered in the scientific enterprise, since the benefits to the starving and the risks of introduction cannot be ignored. There is a need to explore ways to make such products available and to develop the framework for other countries to bring this technology forward with a sound basis in science as well as helping to ensure that the regulatory capacity of these countries is sufficient to offset the risks of biotechnology introduction.

Fourth, the recent Kyoto Water Forum addressed the goal of providing substantially safer water, involving both low and high technology and infrastructure perspectives as well as considering both classic water infrastructure and new technology perspectives. Traditionally, the focus is on large infrastructure investments, yet science must provide the full array of possibilities to decisionmakers to meet diverse needs worldwide.

Other examples included: (1) the need to build in-country scientific capacity to support sustainable development and to advance environmental protection and better human health; (2) improving integration of global observation systems and ground-truthing data to support sustainable development, global climate change, and long-term planning; (3) the 50-year commitment required for global climate change research to help with long-term planning and to deliver better information to decisionmakers; and (4) the need to continue to improve the effectiveness of marine protection (e.g., coral reefs), advance scientific understanding to expand management options and to assess whether the management initiatives are accomplishing the goals, and improve the effectiveness of market-based initiatives such as fish quotas. Expanding the scientific understanding of the management- and market-based techniques and their role in healthier fish stocks, ecosystems, and coral reefs, will support informed policymaking in both developed and developing countries.

A question and answer session with the speaker and audience addressed the following topics: (1) the importance of understanding both the cultural and scientific aspects to support successful introduction of a new initiative; (2) the change in emphasis at the Kyoto Water Forum from large to small systems as well as an exchange of financing ideas, such as the use of a revolving fund

that is prevalent in the United States but not in the rest of the world; (3) the status of decisionmaking on an appeal from the State of Oklahoma regarding the status of a request for assistance from the Council for Environmental Quality to address a complex Superfund site; and (4) the increased understanding of relative risks to improve funding decisions (i.e., help focus funding on highest risk scenarios) as an outgrowth of recent homeland security initiatives.

Science Forum Overview

Dr. Kevin Teichman, Director, Office of Science Policy, presented highlights of the Science Forum activities and presentations.

Director of the Office of Science Policy in ORD, Dr. Kevin Teichman, provided an overview of the three-day *Science Forum* and the comprehensive information packet received upon registration. Dr. Teichman noted the opportunity for participants to view more than 200 posters on the four themes of the *Science Forum* (homeland security, moving science into action, year of water, and emerging technologies), and more than 16 exhibits located in the conference area and outside the building. The afternoon sessions involve a series of plenary talks on each of the four themes featuring speakers from outside the EPA. In the late afternoon poster session, the Science Advisory Board will recognize the recipients of the Level 1 Science Achievement Awards. The second and third days of the *Science Forum* will involve breakout sessions on each of the four themes.

Dr. Teichman noted that of the 1,100 registrants approximately 70 percent were from EPA, and thanked the EPA co-sponsors of this event—EPA Region 4 (moving science into action), OSWER (homeland security), the Office of Water (year of water), and ORD (emerging technologies).

Plenary Addresses

Following introductory remarks by the Associate Assistant Administrator for OSWER, Mr. Thomas Dunne, five speakers addressed each of the four Science Forum theme areas. On the second day of the meeting, the plenary session continued with two additional speakers on the newly-formed EPA National Homeland Security Research Center and the EPA Office of Homeland Security with speaker introductions provided by Dr. Teichman.

Associate Assistant Administrator for OSWER, Mr. Thomas Dunne, introduced the plenary session for the four *Science Forum* theme areas. The last 18 months have seen a growing change in the EPA regarding the types of emergencies addressed and the growing responsibilities in the area of homeland security. Since the terrorist attacks of September 11, 2001, OSWER has responded to emergencies that were very different from those of the past; examples included the collapse of the World Trade Center (WTC), anthrax in the Senate office building, searches for pieces of the Space Shuttle Columbia, and the recent "tractor man" incident in Washington, DC. These represent significant changes in EPA's involvement with emergency response.

Homeland Security

Director for the Biological and Chemical Countermeasures Portfolio, Dr. John Vitko, provided an overview of the DHS, described the identification of needs in the biological area, and

discussed current activities and research initiatives. Federal legislation created the DHS in 2002 with three mission elements: (1) to prevent terrorist attacks in the United States, (2) to reduce vulnerability to terrorist attacks at home, and (3) to minimize damage and assist in recovery. The DHS organization consists of four Directorates: Borders and Transportation System, Information Analysis and Infrastructure Protection, Emergency Preparedness and Response, and Science and Technology (to fill new needs). Creation of the DHS merged all or part of 22 government departments and also involves over 80 external agencies. Therefore, coordination and partnering with other Federal, state, and local government organizations is critical.

The DHS Science and Technology Directorate provides for a full range of research and development including testing, acquisition, and implementation with a focus on responsibility for deployment and acquisition. The internal organization reflects an emphasis on research and applications, including both intramural an extramural research.

A unique organizational feature is the emphasis on portfolios, which integrate across all organizational lines, e.g., biological, radiological/nuclear, and information. The Portfolio Manager formulates the overall vision, sets priorities, and "contracts" with "agents" to manage and execute the work to meet specific objectives and priorities. The Portfolio Manager integrates feedback from interagency working groups, strategic direction from the Homeland Security Council, and the broad science and technology community vision to produce intramural and extramural research, development, testing, evaluation, and systems studies. The Portfolio Manager delegates broad responsibilities and funds for producing the desired end product.

An example is the Biological Countermeasures Portfolio with a mission "to deter, detect, and mitigate possible biological attacks on this nation's population, infrastructure, or agriculture." This portfolio is broad ranging with biological threats involving low, medium, and high sophistication, and must work in an integrated fashion from intelligence through response. An early effort to assess potential catastrophic events and their consequences served to focus current activities on several specific scenarios with selected planning cases to be used to guide and measure initial activities. Efforts are also underway to construct a "report card" to assess or guide an integrated, end-to-end response; this helps to ascertain current status, mid-range goals (in three years), long-range goals (five to seven years), and progress towards achieving these goals. This provides for a top-down, systems-driven picture of the current status and how both threat and technology/response are being addressed. This will also help to focus attention on areas that may prove more difficult to accomplish than originally thought.

Biological attacks differ from all other kinds of attacks and natural disasters, which have immediate and obvious effects. Biological attack can result in exposure over time or may require time after exposure for the biological agent to act. This points to the need to be able to intervene before a biological agent gets too much of a hold in the body. Current efforts in this area are being performed in conjunction with EPA for safe buildings, including detection, air flow control, and evacuation. More challenging to address is a broad city exposure event because response and consequences will be different than for a single building.

Integrated bio-surveillance and environmental monitoring are key to dealing with a broad range of biological attacks. A biowarning system helps to identify the range, how many are exposed, and how broad an area is involved. Environmental monitoring looks for exposure of people or

animals and, once the biological agent is detected, wide area monitoring can be implemented. A nested urban environmental monitoring system is also being pursued that will include wide area monitoring (detect-to-treat), facility monitoring (detect-to-warn), and critical support technologies.

Collaborations occur at multiple levels in accomplishing the DHS mission. At the highest level, DHS is charged to work with other agencies to develop national policy and a strategic plan. DHS set up an interagency committee to accomplish this, including milestones to measure progress. Other interagency working groups are addressing food and chemical analysis laboratories, and EPA is involved in these. In addition, DHS is developing agency-to-agency Memoranda of Understanding (MOUs) for individual collaboration, for example in developing detection and decontamination technologies. DHS will be issuing two major "calls for proposals" in the next few months, which represent additional opportunities for direct partnering and collaboration.

Examples of DHS partnering with EPA at the program-to-program and researcher-to-researcher level include:

- Critical partner in "BioWatch" air monitoring systems for major cities and metropolitan areas
- Programmatic coordination with the EPA Homeland Security Research Center addressing safe buildings, water security, and rapid risk assessment
- Programmatic coordination with the EPA Environmental Technology Verification (ETV) Program on testing and standards
- Diverse research interactions.

Moving Science Into Action

Secretary of the North Carolina DENR, Mr. William Ross, Jr., discussed the Federal/state partnership and how the relationship between North Carolina and EPA are moving science forward in ways that contribute to the environment and human health. Three examples illustrated the Federal/state partnership and demonstrated several themes including the power of science, the power of partnerships, and the power of leadership. Specifically:

- Science provides a better understanding of the life support systems upon which we depend, how we exceed the ability of ecosystems to absorb what we give them, and how things impact our health and well-being
- Partnerships join spheres of influence and provide the ability to draw on resources to accomplish more than one might do alone
- Talented leaders step up to a challenging situation, even though they are not required to do so, and seize the opportunity to move a situation forward.

The first example involved increasing air pollution problems in the Southern Appalachian Mountains ranging from Alabama to West Virginia. Several states, Federal agencies, Federal land managers, private citizens, universities, and other interested parties formed the Southern Appalachian Mountains Initiative to gain better understanding of the air quality in the Southeastern United States. This initiative was voluntary, consensus-driven, and led by the eight states involved. To understand the air quality, an advanced, integrated assessment model was developed and showed that the greatest benefit of NOx and SOx reductions would be in the regions where those were emitted. These results fed into an ongoing debate in North Carolina about whether coal-fired plant emissions should be reduced. While the study itself was not focused on health effects, the modeling helped to achieve better understanding of health effects information coming from other sources. The model results helped to demonstrate that there was a clear need for action and the question then became how to pay for these reductions. North Carolina Governor Easley was able to bring together the utilities and other private entities to accept a rate freeze and accelerated amortization.

The second example involved improvements in wetlands compensatory mitigation for highway construction projects. Various sources indicated that compensatory mitigation was not providing adequate offsets to impacts of road construction on wetlands and streams. The North Carolina Department of Transportation noted that performing such mitigations were also a major cause of transportation project delay and expense. Thus, the existing compensatory mitigation process was not delivering satisfactorily on either the ecologic or process sides. Therefore, the North Carolina Department of Transportation, the North Carolina DENR, the United States Army Corps of Engineers, and various Federal and other agencies involved in permitting highways examined how to improve the process and the benefits. This initiative drew on many programs and information sources about the existing natural environment, and found ways to focus on the functions of a watershed and how to protect those functions by first identifying impacts of the construction then determining how to change stream/wetlands values or functions to compensate for those impacts.

The third example addressed the challenge of maintaining both environmental protection and the military mission at Fort Bragg, which faced limitations on important resources due to a drought affecting the Little River, air-related issues, and an endangered red-cockaded woodpecker. The solution was to find ways to make both the military base and its surrounding region sustainable. An Army officer brought together the North Carolina DENR, Fort Bragg representatives, and other agencies to examine specific issues and to determine how to achieve the necessary sustainability. This process is ongoing, but the enthusiasm of all parties to try to come up with the answers is promising.

Director of the Haudenosaunee Environmental Task Force, Mr. James Ransom, addressed how cultural issues affect science and provided an understanding of the role of traditional knowledge in conjunction with Western science in problem solving. Mr. Ransom focused on three things: use of traditional teachings as a guide to bettering relationships between tribes and EPA, traditional knowledge as a science, and initiatives to create a health and well-being model as a tribal alternative to EPA risk assessment.

The Haudenosaunee Environmental Task Force was created by the traditional governments, but does not work for a specific tribal government. This Task Force provides an opportunity to

create environmental programs based on tribal teachings. The principles that underlie tribal teachings on how to live in harmony with the natural world, which contributed to Native American survival for thousands of years, may apply today. To illustrate this point, Mr. Ransom presented and described an historic wampum teaching belt that incorporates the concepts of the need for good communication, mutual co-operation, and positive contributions to form good relationships. Several examples illustrated how the concepts in this wampum teaching belt provide an analogy for environmental work as well as for relationships between tribes and the Federal government.

The EPA Indian policy was first put in place in 1984 for administration of environmental programs on Indian Reservations. EPA was the first Federal agency to have such a policy, before the Indian Health Service and the Bureau of Indian Affairs. The policy focused on working with tribes as representatives of another government, recognized that tribal governments have the authority to set their own programs, and indicated the willingness to help the tribal government develop their programs.

Culture encompasses government, language, lifestyles, and knowledge systems. Attendees of this *Science Forum* are very familiar with Western science, but may be less familiar with traditional knowledge. When any people live in a particular area for a long time, they gain a knowledge of interactions of all the parts of the natural area. Traditional knowledge is the collective knowledge of a people and is transferred from one generation to the next. The Native Americans consider this a science and the information in this collective knowledge dates back over a thousand years.

Western and traditional knowledge are different but both have value. Traditional knowledge is more holistic (e.g., interest in the big picture), spiritual, and qualitative, while Western knowledge is more analytical, tends to look at small pieces, emphasizes the physical world, and is more quantitative. In additional, traditional knowledge has an ecosystem approach (e.g., interactions of all the parts), while Western knowledge tends to break the ecosystem down into air, water, and other components.

Experience has shown that combining the two knowledge systems results in a powerful problem-solving tool. One example involved a disease outbreak in the Navajo Nation in the early 1990s. Navajo traditional knowledge of precipitation events and their impact on the environment and wildlife enabled the Centers for Disease Control and Prevention (CDC) to identify the hanta virus as the health problem. Both sides had important knowledge, yet neither alone had the solution; joining this knowledge enabled the problem to be solved.

The EPA Tribal Science Council is developing a health and well-being concept. The EPA risk assessment process often fails to consider the relationship of humans and the natural world, cannot measure the spiritual/mental connection between us and the rest of creation, and does not consider the values tribes place on the relationship with the natural world nor the cultural ties or the cost of avoidance of in terms of these relationships. Finally, the EPA model is based on the risk of exposure to toxic chemicals, which measures illness, dying, and death. From the Native American perspective, the model should instead focus on the health and well-being concept—we cannot be healthy if the environment is not. Therefore, it is necessary to identify indicators whether they relate to health or the need to make the environment health. An indicator can be as

simple as the number of picnics held as a community. This is a concept that is just starting to gain momentum.

Year of Water

Marine Biologist and Explorer-in-Residence with the National Geographic Society, Dr. Sylvia Earle, discussed the importance of scientific exploration and its role in understanding water, the environment, and human impacts. The National Marine Sanctuaries Act came into being around the same time as the Clean Water Act (CWA) and the Endangered Species Act among other environmental legislation, and this series of legislation changed both this country and how we perceive ourselves.

Dr. Earle recently viewed a videotape of explorers of underground rivers in Florida. This provides a totally different perspective about groundwater and what influences such places. The videotape also showed how the condition of the water in sink holes has changed since she last explored them. Such exploration helps to engage agencies in the understanding of water and how it is recycled again and again in the environment. Thus, what we drink may have been contaminated somehow, somewhere, and in some way.

While many believe that space and the oceans are the last great unexplored regions, the conclusions of all of the National Geographic Society Explorers-in-Residence is that we are on the edge of the greatest exploration yet. Emerging technologies are providing us the ability to sense the world around us in new ways, and are enabling us to scientifically explore oceans, rivers, etc. In addition, we have learned more in the past 25 years than at any other time in history while at the same time we may have also lost a lot as a result of our own actions to the environment of our world despite the many progressive actions taken and our growing awareness of ourselves and our being a part of the natural system. An example of the loss included the damage incurred to the wildlife riches and ecosystem of Kuwait after Iraqi attacks and oil field fires from the Gulf War in 1991, illustrated in a video clip—one of the largest ecological disasters of all time and involved a deliberate attack on the ecology that affected the suitability of air to breath, water safe to drink, and fish safe to eat. Another example involved Iraqi actions to control the "marsh people" of southern Iraq by reducing the flow of the Euphrates River to destroy the marshes, which can severely impact migratory waterfowl.

Water is becoming a major international issue. Turkey is considering the diversion of some of the water from the Euphrates River upstream of the areas already impacted by Iraqi actions. There have also been many water wars. Water sells for more per ounce than oil in the United States and in the rest of the world.

The amount of water in the world is finite. While most is in the oceans, the issue is availability of water and the ability to access it. We have a water-based planet and our life depends on this. In years past, water was readily availability and drinkable; this is no longer the case and is changing rapidly. Water distribution and contamination is changing dramatically in our lifetime, and therefore sound, safe water is what so many are working on.

A 1991 trip to Kuwait also demonstrated the relationships between human condition and environmental sustainability. The need to restore the Kuwaiti economy involved questions of

food, air, water, and places to live – environment and security. If there is not much to hope for, then desperate actions may occur. Thus, maintaining the integrity of our environment, having a place to live, and having food to eat leads to the need to sustain our systems and ourselves. This is a long-term view when gains today are more and more a short-term horizon. This points to the need to embrace and protect the cultural, historic, and natural heritage. An example illustrating this long-term view is the action taken by President Teddy Roosevelt to preserve special areas within the United States in the wake of massive forest destruction typical of that era.

From an international perspective, all waters eventually connect with one another. The United States has enjoyed a leadership role in this area, yet there are limits to what we can continue to do. This includes taking care of environmental areas for the future as well as new policies for protection and enforcement. Scientific exploration is helping in this area. For example, deep ocean submersibles enable scientists and teachers to go into the ocean environment and observe the dead zones that show the consequences of our actions.

Key questions are what will the world environment be like in 30 years and what are the consequences from today's actions. We have the power to make a difference. Too many decisions are terminal and it is not possible to get back what is lost. Key to this is the understanding that everything is connected and that the knowledge gained from new technologies can make a profound difference for all that follow. A film clip showed how unique conditions came together to form life, how all things are connected, and how anything we do affects our home and ourselves.

Emerging Technologies

Director of the Foresight and Governance Project with the Woodrow Wilson International Center for Scholars, Mr. David Rejeski, discussed the current technology revolution and anticipated future directions. The first industrial revolution began in 1850 to 1860 and was all about oil, coal, and the internal combustion engine. EPA, created in 1970, focused on cleaning up over 100 years of environmental pollution from this industrial revolution and getting the continued pollution under control. The second industrial revolution began in 1975 to 1980, and involves information and biotechnology.

EPA is currently straddling two different industrial revolutions, and the legal methods used to address the first industrial revolution may not be the right tool to address the issues of the second. In addition, the first 30 years of EPA's existence primarily addressed the by-products of production. By 1990, EPA began to switch its emphasis to the products of production (green design, etc.). The next great challenge to EPA is to address production itself.

The current industrial revolution involves how and where things are made, and will involve great changes such as creation of biological chips instead of silicon chips, making products via transgenic animals, and the creation and use of nanomaterials. How such new materials will behave in a landfill is not yet understood. In addition, manufacturing is becoming a mobile, nonpoint source; so, new approaches are necessary since control of such sources with traditional methods may not be possible. This revolution is also about whether things are made (e.g., download onto a CD rather than manufacture) or whether things make themselves via autonomous, computer-based evolutionary design. Since the code inside the computer now

matters (the computer is making decisions), the question becomes what is EPA's role in a virtual world?

EPA is an adaptive agency and must become a shaping agency in the second industrial revolution. Changes in science and technology necessitate changes in the Agency's approaches. The first industrial revolution involved atoms, sharp boundaries, incremental change, and the science of discovery. The second industrial revolution for the near future involves atoms and bits (e.g., digital and physical converge), interconnectivity (fluid, mobile), exponential change, and the science of disruption.

Speed and convergence are new challenges with everything moving much faster. Examples included the doubling of the logic density of silicon integrated circuits every 18 months and the halving of the cost of sequencing deoxyribonucleic acid (DNA) base pairs every 27 months. Different organizations have different clock speeds, with government organizations typically requiring longer reaction time to change than private industry. To overcome this, government agencies may have to fund external entities. An example was the inability of the CIA to develop information technology internally at a sufficiently fast pace, and overcame this by creating an internal venture arm that funded external entities to meet CIA needs.

Early warning becomes critical in a fast-paced world because there is less time to intervene and reverse damages at reasonable cost. Therefore, it is necessary to spend time and energy in developing the science of early warning for ecosystems, etc.

The sciences are converging—bio-info-nano-cogno. Information moves across all these areas with much potential for societal/social impacts. Fluidity in the work force is necessary to move across these areas. There is much talk about the need for multidisciplinary personnel, but the workforce rewards are still focused on staying within one's discipline.

Addressing this second industrial revolution requires a change in thinking and stresses the importance of what is going on all around, not just in a specific field. Without such "peripheral vision" there is no early warning of changes, the loss of context results in unintended consequences, and the response to the changes can be shock, surprise, and the inability to act. There are a number of different peripheries to consider in this industrial revolution, including geographic, idea (accepted knowledge versus new concepts), temporal (thinking several years forward), and intellectual (different styles of thinking). Six ways to destroy the peripheral vision include leadership failure, "not invented here" attitude, goal obsession, adversarial relationships, workforce monoculture with no variety in thinking, and impermeable boundaries. Of great importance is the need to shape the public dialog regarding the ideas from the "peripheral vision" around science and technology.

To effectively address the speed of change issue is to move from learning about consequences "after the fact" to "learning before doing" (e.g., design molecules in a computer, model air issues). This must operate in the science and technology research area since research and development and product/process design is the "learning before doing" scenario. In slow learning/adaptation, environmental impacts are an unintended consequence of technology development and deployment with regulation applied to reduce the impacts. In fast learning/shaping, the environment is co-optimized as part of technology development and

deployment, or may be the primary goal. This is a change that puts researchers not regulators in the driver's seat.

Another adaptive scenario is the "leap." Future thinking tends to be based on the present and the past, and such cognitive processes may interfere in the development of breakthrough technologies. The National Aeronautics and Space Administration (NASA) applied a different "future thinking" approach that considered how to achieve goals unattainable with today's knowledge/technology to help lead to breakthrough ideas and technology. Institutionalizing the ability to take incredible leaps in thinking and to consider previously unattainable capabilities and performance enables extrapolation to achieve breakthrough technologies that result in new instruments, tools, and techniques.

To address this second industrial revolution, new organizational behaviors are needed: continual situation awareness (peripheral vision), capacity to recognize emergent systems and opportunities, high organizational clock speed, and breakthrough thinking. To accomplish this requires new budget priorities, such as establishing and funding an environmental-legal-social implications program as part of the total environmental research budget, focusing 40 to 50 percent of the environmental research on shaping the emerging technological infrastructure (change from mission support to mission control), and establish venture funds (similar to CIA approach) to support high risk, high value, game-changing technologies.

National Homeland Security Research Center and Office of Homeland Security

EPA Deputy Administrator, Ms. Linda Fisher, discussed the newly created NHSRC and its role in supporting EPA responsibilities for homeland security. Ms. Fisher noted the importance of enhancing the Agency's science and scientists, and how this forum provides an opportunity to see how science supports Agency policies and to understand the underlying science.

EPA involvement in homeland security predates the terrorist attacks of September 11, 2001, but EPA's role became more obvious in the post-attack support provided to New York City and the Pentagon as well as in EPA and CDC teaming together to cleanup the anthrax in the Hart Building. This is a tribute to the creativity of the team to determine how to address the problem and to obtain acceptance of the building's occupants (Senators and their staff) for the proposed approach, resulting in a building that is open again to the public.

EPA has two primary areas of responsibility for homeland security: protection of the nation's water infrastructure and serving as the lead agency for cleanup of a chemical attack (with a support role for a radiological attack). For water infrastructure protection, EPA is working with municipal drinking water facilities around the country, has committed $100 million to assist them in performing vulnerability assessments to identify weakness, and is supporting efforts currently underway to address those weaknesses.

To support these efforts, EPA established the NHSRC in Cincinnati, Ohio, with a budget of $50 million and 80 scientists nationwide. NHSRC personnel work side-by-side with Office of Water, ORD, OSWER, and Office of Prevention, Pesticides, and Toxic Substances (OPPTS) personnel also involved with homeland security. NHSRC is a temporary organization with a three-year

commitment to focus on homeland security needs drawing on EPA's historic research role as well as cutting-edge science.

EPA developed a research plan in conjunction with its Program Offices and other Federal agencies whose missions EPA shares or complements, including the Department of Energy (DOE), the Department of Defense (DOD), and CDC. This research plan includes three major research program areas: safe buildings, water security, and rapid risk assessment. The safe buildings component focuses on protecting buildings and their occupants as well as cleanup of building contamination with the goal of communicating information on how to protect the occupants/buildings and what to do in the event of contamination. The water security component is identifying contaminants in drinking water to improve drinking water monitoring and analytical methods, including the development of contingency planning to support water suppliers in providing alternative water supplies. The rapid risk assessment component is developing risk assessment techniques to provide fast answers for first responders and policymakers; this includes the identification and prioritization of different scenarios that might be faced, improving understanding of short-term (acute) and long-term (lifetime) exposure, and examining risks of attacks to understand the types of exposures and what they may mean.

A key question from the public following the September 11th attacks was what effect the contaminants may have for exposures lasting several weeks. This points to the importance of being able to explain after an attack what the exposures and risks are. EPA research will identify current knowledge and gaps in knowledge, then bring together the scientific community to address these gaps to identify scientifically sound actions to protect the American public in the event of another attack.

In addition, the EPA Administrator created an Office of Homeland Security as a focal point to develop policy within the Agency and to serve as the primary liaison between EPA, the new DHS, and other Federal agencies that are working together on these issues. Ms. Fisher introduced Ms. Mary Kruger, Director of the EPA Office of Homeland Security, who briefly discussed the role and mission of this new Office. Emergency response and homeland security include cross-media issues, interagency and intra-agency interactions, and cutting-edge science involving multitudes of stakeholders. After September 11th attacks, each EPA Program Office was involved with homeland security issues as well as interacting across the government in this area. The EPA Administrator formed a working group, which evolved into the new Office of Homeland Security, operating since February 2003 with a staff of five to six persons. Activities include reviewing the EPA strategic plan on homeland security, whether activities are on the right track, and helping the Program Offices address both the ongoing programs and their additional homeland security activities.

Closing Remarks

Concluding the plenary sessions on the second meeting day, Dr. Kevin Teichman noted that while this is ORD's second annual *Science Forum*, this is the first one to include co-sponsors within EPA, specifically the Office of Water, OSWER, and EPA Region 4. Dr. Teichman thanked the partner organizations as well as specific ORD personnel for their efforts in successfully planning, organizing, and conducting this major event.

Section III: Homeland Security

Tuesday and Wednesday, May 6-7, 2003

The purpose of this breakout session on the second and third days of the meeting was to focus on homeland security as it applies to response to past scenarios (e.g., anthrax and the WTC), lessons learned from those events, the building of partnerships among the various agencies, and research and other initiatives to prepare for future threats. Each session included a panel discussion or opportunities to respond to audience questions that provided additional information and insight on a variety of homeland security topics.

Dr. Lee Hofmann, with OSWER, led a session addressing the responses to the anthrax attacks and the research that is being done to develop better response systems. Presentations included descriptions of the remediation activities at the Hart Building and other anthrax contamination sites, an overview of the EPA Homeland Security Research Program, and an evaluation of the re-aerosolization capability of anthrax spores.

Dr. Hofmann also led a session addressing the detection, sampling, and analysis of anthrax involving presentations on the procedures for collecting and analyzing bio-aerosol samples and the anthrax sampling procedures used at the Hart Building.

Ms. Anna Treinies, with OSWER, led a session addressing the fumigation and re-occupancy of buildings contaminated with anthrax. Presentations included a description of the procedures for anthrax decontamination and issues in the determination of building safety for re-occupancy.

Mr. Marty Powell, with EPA Region 3, led a session addressing anthrax decontamination technologies. Presentations included the crisis exemption evaluations for anthrax decontamination chemicals, laboratory evaluation of chemicals for use in the treatment and decontamination of anthrax-contaminated materials, and a research program to further develop efficacy testing.

Mr. Craig Mattheson, with the EPA Chemical Emergency Preparedness and Prevention Office, led a session addressing the partnerships that are being built to support homeland security and terrorism response. Presentations included security plans and communication tools being developed by private industry, emergency response lessons learned for water supplier and wastewater systems, threat reduction actions taken by a water utility, risk assessment for vulnerability assessment methodologies, highlights of the EPA Water Protection Task Force activities, and an overview of the EPA Safe Buildings Program.

Mr. Thomas Coda, with the Office of Air Quality Planning and Standards (OAQPS), led a session focused on the development nationwide implementation of the Bio-Watch Early Detection System.

Mr. Larry Reed with the National Institute of Environmental Health Sciences (NIEHS), led a session addressing lessons learned from the WTC response with respect to exposure and personal protection. Presentations included challenges encountered with interagency collaboration, descriptions of the health and safety issues encountered at the WTC site, the physical and chemical challenges encountered in the response, health effects for cleanup and recovery workers, and an overview of the World Trade Center Assessment Report addressing exposures and health effects for the exposed public and recovery workers.

Dr. Jafrul Hasan, with the Office of Science and Technology in the Office of Water, led a session addressing activities underway to prepare for bioterrorism threats in water. Presentations included a perspective on the wide-ranging impacts of a biological attack, an overview of the EPA Water Security Research and Technical Support Program, technologies potentially applicable for detection of biological threats in water, development of "early warning monitoring" and sensor technology, and highlights of an initiative to develop a protocol for detection of biological agents.

Anthrax: Response and Research

Following opening remarks by Dr. Lee Hofmann, with OSWER, three speakers addressed the remediation activities at the Hart Building and other anthrax contamination sites, the EPA homeland security research program, and evaluations of the re-aerosolization capability of anthrax spores.

Anthrax Response and Recovery: Applied Science and Technology, and Future Needs

Deputy Regional Administrator of EPA Region 3, Mr. Thomas Voltaggio, discussed the response actions taken at the Hart Building immediately following the anthrax contamination, the reasoning behind those actions, the cleanup methods, and the results of those efforts. The anthrax contamination in the Daschle suite is the first large-scale bioattack ever to occur in the United States, and was addressed through a multi-agency response effort aided by the support of EPA, CDC, the National Institute for Occupational Safety and Health (NIOSH), and the United States Capitol Police.

An unprecedented level of effort was required to clear the entire Capitol Hill Campus, which consisted of 30 to 40 buildings and 15,000 employees. The initial role of the EPA was to aid in the sampling efforts. The sampling strategy was to sample the areas of the initial anthrax hits (the Daschle suite), then to follow the trail of the mail to determine how the anthrax spread from the location where the letter was initially opened. The owners of the building subsequently put EPA in charge of the cleanup efforts.

The cleanup was divided into two sites: the Daschle suite (where the letter was opened) and cross-contamination sites with efforts focused on the mail room. A command post was set up in the Botanical Gardens, where the response was organized. Teams from Health & Safety, Sampling & Analysis, Contracts & Resources, and Disposal were onsite to aid in the organizational efforts. Chlorine dioxide liquid was selected for spot cleaning lightly contaminated areas. However, a different mechanism of contamination in the Daschle suite necessitated the use of a different remediation method. Chlorine dioxide gas was chosen as the fumigant for the Daschle suite based on pilot testing, which indicated that the gas breaks down rapidly (reducing residual risks), no breakdown products of concern are formed, and it has been used safely in other areas of commerce. The initial plan to fumigate the entire building underwent peer review, which resulted in a decision to fumigate only the Daschle suite and the heating, ventilation, and air conditioning (HVAC) system.

Establishing a cleanup goal was difficult uncertainty in defining a safe level of anthrax spores. A risk management decision was made that areas would be sampled and, if anthrax growth was found, those areas would be spot cleaned. In addition, materials would be removed from the building and cleaned with aqueous chlorine dioxide.

Fumigation of the Daschle suite took place on December 1 and 2, 2001. Chlorine dioxide was mixed in an onsite generator outside of the building. The HVAC system was cleaned from the basement of the building. The fumigation had to be done twice. A high efficiency particulate air (HEPA) vacuum was used in the areas that were porous. Post-cleanup restoration included the

replacement of carpet and ceiling tiles. A room-by-room review was conducted to evaluate the cleanup efforts, and the efficacy of the treatments was tested by sampling for growths and by using thousands of spore strips in the Daschle suite. Aggressive air, swab, and wipe sampling was conducted prior to reoccupation and, upon clearance by the Assistant Physician for the Capitol, the Hart Building was reopened on January 22, 2002.

There were many lesson learned from this cleanup effort. There were command structure issues in that there was no model for legislative branch roles as well as uncertainty as to who was in charge, considering it was really a police incident. The project had challenging schedule demands, and credibility is lost when such schedules are not kept. The stretch on resources concerning the unique health and safety issues of this undertaking demonstrated the need for improvements in contracting support. In addition, early coordination is critical for disposal of such unique cleanup wastes.

EPA's Homeland Security Research Program

Director of the NHSRC, Mr. Timothy Oppelt, discussed the Homeland Security Research Program's foundation and current activities. The NHSRC opened in October 2002 and, due to the great sense of urgency to address this type of work, was established drawing from existing staff from EPA research organizations in order to be operational as soon as possible with staff experienced in such areas as indoor air pollution, site remediation, analytical methods, and water supply.

The research program consists of three components: the protection of water systems, the protection of buildings, and rapid risk assessment in the aftermath of events. The research program goal is a three-year process to explore ways to provide methods and guidance for preparedness, detection, containment, and decontamination of facilities as well as an understanding of the risks with an emphasis on chemical and biological attacks. The scope of the program, in terms of the hazards, involves:

- Examining the pathogenic bacteria (whether they are weaponized or not)
- Viruses and bacterial toxins
- Chemical warfare agents that have been developed
- Toxic industrial chemicals produced in large volumes that could be used in attacks (e.g., chlorine, anhydrous ammonia, etc.)
- Toxins that could be used in attacks on water systems
- Radiological contamination in drinking water.

The success of the research program depends on partnerships between NHSRC, other EPA and government organizations, and the private sector. Key NHSRC internal collaborations include the Office of Water, Water Protection Task Force, OSWER, Office of Pesticides Program (OPP), and ETV. External collaborations include the United States Army, specifically the Edgewood

Chemical and Biological Center; CDC; United States Air Force; DHS, DOE, and DOD. These collaborations will focus on key knowledge gaps using a two-pronged approach: the use of lessons learned in identifying immediate research needs, and the identification of key threat scenarios that could result in large impacts and are technically feasible and probable. The examination of attacks on chemical production facilities is the responsibility of EPA rather than NHSRC at this time.

The results of screening level simulations and risk analyses currently being conducted will drive priorities for technological needs. The results will also be used to produce final verification tools towards the end of the program, and to provide technical guidance to the Agency and decisionmaking officials. The seven key pieces of the research program are characterization, detection, prevention, containment, decontamination, risk assessment, and scientific back up. Mr. Oppelt provided examples of the research, and the questions driving that research, associated with each of these key program areas noting that there is no emphasis on new technology development. Instead, the primary emphasis is on the application of commercial technology. This research is short-term, high intensity, and highly focused on user needs (i.e., first responders, owners and operators of buildings, and water system operators).

Secondary Aerosolization of Viable *Bacillus Anthracis* Spores in an Office Environment

Toxicologist and Coordinator for Homeland Security at EPA's National Enforcement Investigation Center (NEIC), Dr. Chris Weis, discussed the role of Science Support Coordination (SSCs) for environmental emergencies and the practical safety and risk assessment problems facing On-Scene Coordinators (OSCs). Dr. Weis also discussed the procedures used in the decontamination of the Hart Building after the anthrax attack, and the rationale behind those procedures.

An SSC is any scientist who provides onsite support, and is most often the OSC. The SSC will coordinate science support needs and reach out to whomever is available to answer practical questions. Examples were provided of situations where the SSC was used successfully in the aftermath of environmental events. Rapid risk assessment as well as chemical and biological knowledge are essential to onsite coordination efforts.

The anthrax decontamination of the Hart Building was a collaboration among scientists from various agencies, specifically the United States Army Center for Health Promotion and Prevention Medicine (CHPPM), EPA Region 8, EPA Region 5, and the Navy Biological Defense Directorate. Practical questions surrounding the decontamination efforts included:

- Would the personal air tanks have to be carried with the cleanup personnel?
- Would it be possible to alternatively use air-purifying respirators (APRs)?
- What were the principle and secondary pathways of exposure in the Hart Building?
- Is it possible for the anthrax spores to re-aerosolize?

Formation of the study design was based the decision of what was to be measured, how it was going to measured, and what the endpoints of the study would be. The study design involved stationary (surface, dust, and swab) sampling and personal air sampling under both minimal and

simulated active office activity. Nominal spore sizes and airborne concentrations were measured. Anthrax colonies were grown and the particle diameters were measured using a cascade impact device. In an effort to avoid a secondary extraction step, spores were pulled directly from the desk onto a gelatin filters, then transferred to sheep's blood augers. This procedure allowed the quantification of the surface contamination.

The study revealed that viable anthrax spores do re-aerosolize under both quiet and active office conditions. Greater than 80 percent of the spores were measured within the respirable range (under three microns). However, no spores were measured at a diameter small enough to pass through the APRs (smaller than about one micron). Therefore, it was determined that APRs could be used safely in the cleanup efforts. EPA assessed the risk of isolation of spores, and determined that routine activity in the area of spore contamination could cause reaerosolization. An important aspect is to not expect a bioterrorism agent to behave according to a pre-existing understanding or dogma.

Anthrax: Detection, Sampling, and Analysis

Following introductory comments by Dr. Hofmann, with OSWER, two speakers discussed the procedures for sample collection and analysis of bio-aerosols. A panel discussion including an audience question and answer period followed the presentations.

Environmental Sampling of Bio-Aerosols

Captain Kenneth Martinez, an Industrial Hygienist with NIOSH, discussed the strategies and procedures involved with the decontamination of the Hart Building. At NIOSH, the understanding of organisms is broken down into two categories (obligate parasites and foculative saprophytes), and that much of what is known is based on recognition, evaluation, and control.

Exposure assessment of the anthrax contaminated Hart Building was difficult because most of the existing exposure assessment tools are designed for clinical operations. Difficulties were encountered in adapting these analytical techniques for use in the environmental arena. Onsite health concerns included infections, immunologizations, and toxic effects. A characterization of the size of the anthrax spores needed to be conducted. It was known that the spores respirable, very resistant to environmental extremes, and that electrostatic properties have an effect on the spores. The endemic nature of the spores was determined to be negative. Of the 10,000 samples taken, there were no positive background samples. Each contaminated letter contained a very high concentration of anthrax spores, approximately 1 to 2 grams in each.

Surface and air sampling characterized what had settled and what had been re-entrained into the air. Factors to consider in understanding aerosol particle behavior include the settlement of particles, impaction of the particles, charge effects, particle releases from surfaces, and agglomeration/de-agglomeration of particles in the air. Anthrax spores behave like a gas in that they remain in the air for a very long period of time, and the spores settle differently in stagnant and turbulent air. Pathways for particle transport included doorways, vents, and people moving from one location to another. Determination of what the samples meant was a challenge given the absence of numeric criteria for interpreting such environmental measurements.

Preparation for sampling included training of NIOSH and other sampling personnel, safety precautions (posted on the CDC website), and appropriate record keeping and documentation. Investigative strategies involved following the trail of the mail, examining high traffic areas and ventilation systems, and examining all areas that could potentially collect dust. Sampling considerations included:

- How the spores will be disseminated through air or materials
- Sampling methods based on the porosity of the surfaces
- Validated sampling protocols
- How the methods of analysis will be applied.

Also important was whether the purpose of the environmental sampling was to determine the presence of spores or the extent and degree of contamination, whether the data from the sampling supported medical treatment and cleanup decisions, and whether the results provided guidance on re-occupancy.

Furniture, floors, the ventilation system, vehicles, and clothing were sampled. Issues surrounding the sampling efforts included collection efficiency of instrumentation, recovery efficiency, limits of detection, confirmatory testing, and sample shipping. Most of the samples taken were either bulk or surface samples, although some were air samples. An important aspect is to determine which sampling method is going to be most effective in each area. The surface sample study resulted in the following conclusions:

- Swabs are effective for use in cracks and crevices
- Wipes are effective for light dust loading on non-porous surfaces
- Vacuums are effective for heavy dust loading and for large areas.

Anderson devices were the most consistent/sensitive for air sampling. Andersons have lower processing risks and quicker turn-around times, and there is less laboratory bias resulting from the reduced amount of processing. Recommendations for event responders are available on the CDC website and include the importance of decontaminating the samples as well as people before they leave a contaminated area and that sampling strategies will differ from place to place.

The strategic plan developed by CDC has most of the sample analysis being conducted through the multi-level (A through D) Laboratory Response Network. Level A laboratories are clinical laboratories used to rule out potentially dangerous substances. If a substance is determined to be a potential danger, it will be sent to a level B, C, or D laboratory, as applicable, for further analysis.

In addition, procedures for shipping samples extremely important. Packaging must be rigorous, and all samples must be appropriately labeled as infectious substances. Triple packaging is required with a primary container to hold the samples, a secondary container to provide waterproof protection, and the outer packaging providing durability. The contents of the package must be document as being hazardous. Training is required for those that will be handling the packages.

Collaborations with the industrial, agricultural, and environmental communities are likely in future research efforts. Much of what has been learned in the last 18 months regarding anthrax is now being applied to the current Severe Acute Respiratory Syndrome epidemic.

Mr. Mark Durno, an On-Scene Coordinator (OSC) in the Emergency and Response Branch of the EPA Region 5 Superfund Program, discussed details of the sampling procedures used at the Hart Building.

The first responders made a number of mistakes resulting in cross-contamination of the building by leading Daschle suite employees through hallways and stairwells. EPA led the initial review team and NIOSH, CDC, CHPPM, and DOD aided in the initial sampling assessment. The National Institute of Standards and Technology and the EPA Analytical Operations/Data Quality Center helped with air modeling and mapping of the site. The pathways were followed and 124 samples were collected, of which 12 were positive for anthrax spores. Contamination pathways also included the trail of the mail and foot traffic areas. Sampling all components of the HVAC system tested the air contamination pathways. Air sampling methods included gelatin, Anderson cascades, dry filter units, and open agar plates. Sample characterization results identified anthrax contamination in 11 suites, three committee rooms, one bathroom, three hallways, one elevator, and three stairwells.

Full characterization involved sampling every desk and mail bin, every monitor screen, and high traffic floor areas. The results of the full characterization revealed that very few rooms were contaminated. Composite sampling of all horizontal work spaces was conducted in every room so that individuals could return to their workstations knowing that there was no residual contamination in their areas. Of the four suites that had positive anthrax hits (in addition to the Daschle suite), only one was found to have any additional contamination. This sampling effort involved the collection and management of 10,000 samples and associated data by four to eight people.

Post-remediation sampling was the biggest challenge in the Hart Building response. Sampling was conducted on floors, every horizontal surface, all drawers, and ceiling plenums. Tried and true methods of air sampling were used with final decisions made by best professional judgment.

This bio-aerosol sampling approach is described in the Anthrax Technical Assistance Document, Chapter 6, available on the following website: www.nrt.org. Considerations for pre-remediation sampling include the goals for the sampling efforts, data objectives, keys for a successful strategy, lessons learned in addressing the absence of current standards, and sampling plan development. Objectives of pre-remediation sampling should be developed in consultation with professionals (e.g., medical, public health, industrial hygiene, laboratory, building experts, and local, state, and Federal agencies). The sampling approach should consider monitoring, screening, bulk material, questionable articles, extent of contamination, effectiveness of decontamination, clearance for re-occupancy, transitional sampling, and consideration of every sample as potential crime scene/forensic evidence. In addition, the sampling approach should be logical and systematic, scheduled, and risk-based. The decision to use a targeted or statistical approach should be made depending on the available information. Other aspects of site remediation discussed in the Anthrax Technical Assistance Document include: methods, analytical, transportation, coordination, and interpretation of data.

EPA Region 5 also developed Regional Sampling Guidance that provides equipment use guidance. This booklet is currently in draft form, and is not yet available for distribution.

Panel Discussion/Questions and Answers

The speakers had an opportunity to participate in a brief panel discussion drawing upon questions from the audience.

A brief question and answer period addressed topics. These included: (1) speculations of effective doses of anthrax for healthy and susceptible persons and the minimal number of spores required for determining a test to be positive; (2) the question of a second contaminated letter; (3) the New York City subway incident; (4) sampling at the outlet port; (5) best guesses for exposure at a site, given limited sampling a capabilities; (6) suggestions for outside sampling areas; (7) making the distinction between cultured and naturally occurring spores, and the possibility that persons infected by naturally occurring spores are not diagnosed; and (8) advice for planners.

In closing, Dr. Hofmann thanked Mr. Martinez and Mr. Durno for their presentations and encouraged the audience to visit the displays in the courtyard.

Anthrax: Fumigation and Re-Occupancy

Three speakers addressed the procedures for anthrax decontamination and evaluation to determine the safety of re-occupancy.

Fumigating Anthrax-Contaminated Sites: Building on Experience

Chief Scientist for Bioterrorism Issues in the OSWER, Dr. Dorothy Clark, discussed the remediation of multiple sites as a result of the anthrax mail attacks. The 1999 Consensus statement on anthrax as a biological weapon, produced by the Department of Health and Human Services (DHHS) Working Group on Civilian Biodefense, was tough to sell to Congress. The 2002 Consensus statement was updated and suggested that only experienced personnel should participate in remediation efforts.

Anthrax-contaminated sites included media offices in New York City and in Boca Raton, Florida (AMI), postal facilities, the Capitol Hill complex, and private residences. The NBC, ABC, CBS, and New York Times media offices received letters containing cutaneous anthrax, which is not nearly as dangerous as inhalation anthrax; treatment with antibiotics produces an 80 percent survival rate in persons infected with cutaneous anthrax. However, the Capitol Hill complex and the AMI building in Florida were contaminated by letters containing inhalation anthrax. Therefore, these latter two sites required site remediation (i.e., fumigation).

Anthrax site remediation processes include site assessment, isolation of contaminated areas, artifact/critical item removal, source reduction (via HEPA vacuum), post-remediation sampling, further remediation (as needed), and disposal of decontamination materials such as decontamination water, expendable personal protective equipment (PPE), and debris. Associated environmental sampling processes involve:

- Confirmation of the existence of contamination
- Characterization of the nature/extent of the contamination
- Aid in selecting a remedial approach
- Determination of the effectiveness of remediation
- Contributions to decisionmaking on re-occupancy.

The New York City media offices, the Capitol Hill complex, and the Department of Justice (DOJ) mail facility have undergone complete remediation. Remediation of General Services Administration (GSA) Building 410 is currently underway. The Annex-32, Hamilton, and AMI building remediations are in the planning stage.

Sites requiring fumigation remedies are those that are contaminated with inhalation anthrax or that have areas with high concentrations of dangerous spores. These sites include the Hart Senate Office Building, DOJ mail facility, Brentwood Post Office, Hamilton, GSA Building 410, Annex-32, and the AMI building. Fumigants being used at these sites include:

- ClO_2 – at the Hart Senate Building, Brentwood, and Hamilton

- Vaporized hydrogen peroxide – at GSA Building 410 and Annex-32

- Paraformaldehyde (historically used by medical, academic, and army labs to cleanup anthrax) – at the DOJ mail facility.

Fumigant selection is a site-specific decision. A match between the fumigant chosen and the agent of contamination, the decontamination process, and the site requiring treatment is essential. Drivers for use of gaseous treatment include the concentration of the contaminant, exposure time, relative humidity, and temperature. When using ClO_2 gas, it is important that the relative humidity be greater than 70 percent, and it is best to have a certain conditioning time prior to introduction of the gas to ensure that enough moisture gets to the spores.

An Anthrax Fumigation Evaluation Project is funded by ORD as part of the Homeland Security Research Program. This project is slated to begin July 1, 2003 and will involve an in-depth analysis of a group of representative anthrax fumigations. The analysis will include three different fumigants and will draw on a multidisciplinary team of experienced personnel. Aspects of fumigation remedies considered in this study include:

- Environmental sampling—nature and extent of pre-remediation sampling and sampling during remediation

- Pre-fumigation source reduction activities—removal of materials from the site and the nature and extent of surface treatments

- Safety—containment of the space to be fumigated, extent of pre-fumigation testing for key equipment, action levels for ambient concentrations of agent, monitoring for leakage of the

fumigant, removal of the fumigant at the end of the fumigation process, and adequacy of emergency response plan

- Efficacy—selection of fumigant based on penetrability (toxic properties, materials compatibility, history of usage/success), post-treatment aeration to address residues, cost considerations, generation of agent onsite, control of process variables (temperature, relative humidity, concentration, and exposure time), minimum conditions necessary to continue in each phase of the fumigation process and to progress to the next stage, and site-specific considerations (e.g., fumigate the entire building or just a section, need for redundancy of key equipment, containment of area, distribution of gas, circulation of gas, measurement of process variables, and aeration)

- Cost/downtime—cost issues, national security issues, and public opinion

- Output—a report for each site in the study to include an evaluation of alternative mechanisms for maintaining containment, an evaluation of cost, and documentation of methods to enhance future fumigation.

Clearance Determinations: Judging Remediation Success and Readiness for Re-Occupancy

Mr. Matt Gillen, with NIOSH, and Mr. Jack Kelly, with EPA Region 3, discussed a joint CDC/EPA project, focusing on the general approach, scientific issues, lessons learned, and information from published reports, regarding clearance determinations for post-remediation building re-occupancy.

Mr. Jack Kelly, an OSC with EPA Region 3, provided an overview of the remediation process. The entire remediation process includes the following: a contamination event, an initial response/outbreak investigation, facility closure and isolation, a characterization sampling phase, development and approval of remediation and clearance plans, remediation activities, clearance verification sampling, evaluation of the clearance/technical determination, a period of refurbishment, and re-occupancy.

Clearance comes at the end of the remediation process, and involves an expression of interest or request from the facility owner, creation of a cross-disciplinary Environmental Clearance Committee (ECC), ECC briefing by facility owner and remediation team, ECC input into the sampling plan, ECC review of clearance data upon completion of remediation activities, preparation of technical determination statement, and assistance with risk communication (if requested).

The three key clearance issues are organization, technical/scientific, and communication. Organizational issues include:

- Determining the need for and benefits of using an ECC.

- Usefulness of multidisciplinary peer review when there is a significant contamination event, a complex cleanup, a need for an independent opinion, a need for external assurances, or a novel situation with no established cleanup procedures.

- Selection considerations for the ECC chair person and committee candidates. EPA and local health department representatives have served as co-chairs. Participants can be drawn from all levels of government, military, and private sector/academia, and selection should cover pertinent disciplines. Generally, the ECC has not been used as a mechanism for stakeholder involvement.

- ECC reporting, including the need to present a recommendation that either remediation has been successful or that additional actions are needed with reports provided to the facility owner.

- The scope of the ECC review, which is all information necessary to reach a decision on re-occupancy.

- The need for the ECC to be an independent function with ECC chair person(s) providing a liaison to facility owner through at least two coordination meetings; cooperation of the facility owner/operator is crucial for the ECC to perform its duties.

- The usefulness of a charter to define goals and responsibilities of the ECC and to address expectations of both the ECC and the facility owner/operator. This helps to prevent surprises and avoids misunderstandings. The charter can be structured as a "charge" to the ECC or in the form of a possible list of questions.

Another organizational consideration is the role of a technical working group and its relationship to an ECC. A technical working group provides input earlier than ECC on aspects such as the remediation plan during the EPA crisis exemption evaluation. In some cases, technical working group members may also serve on the ECC. There are advantages and disadvantages to each of these approaches.

Related organizational issues include whether ECC members serve as individuals or as representatives of their Agency, and defining the relationship between the ECC and the facility owner/operator.

Mr. Matt Gillen, a Senior Scientist with NIOSH, discussed the technical/scientific issues. The overall goals of this joint project include the use of the best science available; the acquisition and use of high quality data; the use of valid, effective methods; incorporation of new scientific developments; conduct of thorough and rigorous clearance sampling; and use of "negative growth" as the clearance criterion for judging the success of remediation efforts.

Technical challenges and research gaps faced in this project include the lack of a detection limit, formally validated methods, and risk-based cleanup criteria to address the question of "how clean is clean?" CDC testimony states (in regard to the Brentwood Post Office) "…it is the goal of CDC to minimize illness and disease to the greatest extent possible…."

The clearance sampling test sequence involves the following steps: spore strip testing (biological indicators), surface sampling, then aggressive air sampling. Sampling strategies used for clearance include focused sampling to target previously positive locations, biased sampling to target other most likely locations, and grid/random sampling to systematically check other areas of the facility.

Mr. Jack Kelly, with EPA Region 3 discussed the communication issues. One issue involves the independence of the ECC, which is dependent for information, but independent for evaluation. Another issue is how the ECC handles a lack of consensus in decisionmaking with consensus being the preferred route, but with the use of minority opinion if necessary. A third issue involved the ECC's role with regard to returning workers. Recommendations were for such deliberations and discussions to occur in a "closed" venue with ECC members available to the public for question and answer.

A further communications consideration is the nature of the formal statements provided by the ECC and to whom those statements are provided. Short statements addressed to the Incident Commander or other relevant authority that serve as technical determinations are preferred, should be written for a general audience with the inclusion of technical terms and caveats where needed, and should be suitable for public release.

Highlights of this joint project include:

- Organizational—the first use of the ECC concept, recognition that public health agencies should be involved in re-occupancy and reuse decisions, and how the ECC members pulled together

- Technical/Scientific—sample analysis, composite samples, surface sampling, first use of aggressive air sampling, room-by-room clearance approach, and the importance of outreach sessions for returning workers

- Communication—the "no-growth" cleanup standard for the Brentwood Post Office, and the interim statement provide by ECC; public availability of the decision document is being assessed.

Lessons learned in conducting this joint project include the importance of determining whether an ECC is needed or wanted, the need for all parties to know their roles and responsibilities, confidentiality issues, consideration of forming an ECC of experienced personnel from non-regulatory government agencies and academia/private industry, debate over ECC members serving on a technical working group, and the make up of the ECC membership.

Panel Discussion/Questions and Answers

The speakers had an opportunity to participate in a brief panel discussion drawing on questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) the obligation of the sampler to describe expected risks; (2) sampling work done in the Hart Building

following re-occupancy; (3) application of the ECC concept to privately owned buildings; (4) technical documentation of these approaches; and (5) clarification of who provides clearance, clearance policies, and experiences with local governments.

Anthrax: Decontamination Technologies

Following opening remarks by Mr. Marty Powell, with EPA Region 3, four speakers addressed the determination and evaluation of chemicals for use in the treatment of anthrax contamination. A panel discussion including an audience question and answer period followed the presentations.

The Hunt for Anthrax Contamination Chemicals

Mr. Jeff Kempter, Senior Advisor to the Antimicrobial Division of OPP, discussed the crisis exemption and the challenges involved with cleanup efforts at anthrax sites. The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) requires that a pesticide be registered before it can be distributed or that it be exempted for emergency purposes. FIFRA defines a pesticide as any substance intended to prevent, destroy, repel, or mitigate any pest, and defines a pest as any form of plant or animal life or virus, bacteria, or other micro-organism, except on or in living man or animals. In regulating decontamination chemicals, anthrax has been defined as a pest.

The standard for EPA approval of a product as a pesticide requires demonstration that the product may not cause unreasonable risk to humans or the environment, demonstration of the benefits or efficacy of the product, and demonstration that the product cannot cause unacceptable human dietary risks.

Pesticide registration requirements include the provision of information on the product and its composition (chemicals, inert components, production, source of active ingredients, etc.), the toxicity of product, efficacy of the data, and product labeling. The product may be new or amended.

Efficacy data for sterilants are currently tested using the AOAC Sporicidal Activity Test. This is a qualitative carrier test for both hard and porous surfaces. Success is measured as "zero growth" on all 720 carriers in the test.

The crisis exemption has been set up for anthrax decontamination chemicals. Approval of a crisis exemption requires submission of safety and efficacy data as well as sampling and monitoring plans. To date, 54 crisis exemption requests have been received from Federal agencies, companies, and registrants resulting in 21 exemptions issued, 27 requests rejected, 4 requests pending, and 2 requests withdrawn.

Liquid chemicals approved for crisis exemption (for hard surfaces only) include: Aqueous ClO_2, hydrogen peroxide/peractic acid, sodium hypochlorite, and hydrogen peroxide/quaternary ammonium compound (foam). Gases approved for crisis exemption include ClO_2 gas, ethylene oxide, paraformaldehyde, vaporized hydrogen peroxide, and methyl bromide.

There are six major challenges involved in the cleanup of anthrax contamination. The first challenge is the actual cleanup of the contaminated sites and involves the following issues: the building owner, EPA, and other agencies must work together at each site, technical working groups and ECCs should provide expert guidance, and crisis exemptions need to be approved for chemicals to be used onsite. The second challenge is in the documentation and evaluation of cleanup efforts and involves the following: comprehensive reviews of major site cleanups; the evaluation of different decontamination chemicals as to their effectiveness, safety, and cost; and the objective comparison of cleanup methods and distillation of lessons learned. Other challenges involve the validation of efficacy test methods, research and development of decontamination technologies, preparation for other biological agents, and preparation for new and emerging pathogens.

Mr. Jeff Heimerman, with the OSWER Technology Innovation Office (TIO), discussed the evaluation of new and emerging technology. To relieve the burden of the emergency center, a clearinghouse website (www.epatechbit.org) was established. The EPATechBit Helpline aids in answering questions on efficacy data and related information. To date, 51 decontamination devices and various other technologies are included on the website.

Meetings have been held by a "Red Team" in an effort to focus on developing a systematic approach for examining these new technologies, since the quality of information received to date has not been good. All input has been unsolicited and included broad claims but no supporting data. To address this, an example building scenario was developed to test these technologies. The evaluation model was based on a schematic weighted scale, which included environmental conditions. An evaluation chart was also developed.

The Red Team noted during their review process that the lack of test data is a hindrance to evaluation. This evaluation process may be a useful tool to use as triage for technology, and that a cross-agency body of people who believe in this type of technology is needed.

Gaps in this process include the need for a triage function to determine when vendors should be directed to other agencies and how others should be prioritized into the ETV program. Also needed is the development of a more permanent vendor tracking system.

Laboratory Support for Evaluating Decontamination Technologies

Ms. Rebecca Schultheiss, with the EPA Environmental Science Center at Fort Meade, Maryland, discussed the duties and capabilities of this laboratory in evaluating decontamination technology and techniques. The Environmental Science Center is a state-of-the-art, biological level safety 3 microbiology laboratory, which provides support to OPP, conducts efficacy testing of antimicrobials, and participates in other projects such as genetically modified plant methods, method development, and semi-quasi mode research.

The Environmental Science Center supported the Hart Building and Brentwood Post Office decontamination evaluations. For example, spore strip analysis was conducted prior to fumigation for the Hart Building, and this analysis supported the development of PPE requirements during remediation. Line 17 analysis was conducted for the Brentwood Post

Office. In addition, testing was also conducted to assess contamination of chemical decontamination solutions and to assess the success of fumigation.

One of the roles of the Environmental Science Center is to provide guidance. This included the conduct of trial tests of the decontamination capability of bleach, ClO_2, and decontamination foam. Eleven trials were conducted to test a range of bleaches, contact times, and unadjusted pH solutions. pH was found to be a significant factor in the trials for successful use on nonporous surfaces. Since porous surfaces treated with bleach have not passed the test, the Agency decided to take a conservative approach to the use of this product.

Four liquid ClO_2 trials were conducted that involved different contact times as well as porous and non-porous surfaces. The ClO_2 passed the tests for nonporous surfaces. After several failures, the evaluation of ClO_2 for use on porous surfaces was halted.

Decontamination foam was originally given a crisis exemption. Decontamination foam comes in two parts, liquid and powder, that must be mixed together. The trials conducted at the recommended 1-hour contact time for both porous and non-porous surfaces failed. As a result, the Section 18 Crisis Exemption was lifted.

Issues encountered during these trials included:

- Need for range finding studies
- Critical role of pH for a successful decontamination outcome
- Neutralization of the active ingredient was critical
- Carrier count method had to be refined resulting in the development of a more accurate method.

In addition, the qualitative test only evaluated growth or non-growth.

On-going activities of the Environmental Science Center are focused on developing an improved evaluation method. Future challenges include:

- Dealing with the organism and its surrogates
- Re-evaluating the use site, as it has now changed to large buildings and airplanes
- Developing methods to determine effications of spore size
- Identifying materials that will work on porous surfaces.

Efficacy Testing Science Issues and Follow-up Research

Dr. Stephen Tomasino, Team Leader at the Environmental Science Center in Fort Meade, Maryland, discussed the complex nature of determining the effectiveness of antimicrobial chemicals, EPA's role in developing an efficacy testing strategy to advance the science, and the research plan. Measuring efficacy is complex and involves the following issues:

- Micro-organisms may or may not grow (depending on their nature), making them more difficult to deal with than chemicals

- Some of this information/technology has not been updated for decades

- Difficulty in simulating porous/hard surfaces

- Absence of textbook expertise requiring technical expertise to be handed down and developed over time

- Controlled conditions are necessary and expensive to simulate

- Recovery of both viable and damaged spores is difficult.

Factors affecting efficacy testing include concentration, formulation, application method, application rate, dilutent, contact time, temperature, organic burden, treated surface, product age, pH, and test microbe. The Environmental Science Center is attempting to design and evaluate a method that combines formulations and materials. Important decisions include the formation of a test subgroup and formation of subgroups for surrogates and gases and vapors. In addition, test method evaluation attributes include cost, readily available equipment, expertise, flexible contact times and temperature, methods sensitivity, adequate controls, enumeration method, percent recovery, deactivation of product, reproducibility, turnaround time, and validation.

The goals of the research plan are to:

- Replace or improve the current qualitative method (AOAC Sporicidal Test)
- Study quantitative methods for liquids on hard surfaces
- Perform comparative side-by-side testing
- Comparative efficacy data are essential to the development of future regulatory guidance
- Develop expertise in conducting multiple sporicidal tests
- Perform statistical analyses to determine mean, variances, etc.
- Select two quantitative methods for further investigation and validation testing.

Activities to be conducted in the remainder of 2003 involves the development of standard operating procedures and a QA document, training and practice, performance of pre-collaborative studies, initiation of research in late summer, compilation of data and performance of statistical analyses, and reporting findings to Federal agencies. Future plans for the this research effort include the addition of surrogates to the testing matrix, exploration and testing of a variety of materials, pursuit of a screening method, conduct of validation testing, and evaluation of field test methods.

Panel Discussion/Questions and Answers

The speakers had an opportunity to participate in a brief panel discussion drawing in questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) the need for registration of a product for multiple uses; (2) tests conducted with anthrax and concrete; (3) the possibility of using a 14-day spore strip analysis; and (4) the incubation time period necessary for successful germination of cells.

Building Partnerships Towards Homeland Security

Following opening remarks by session moderator, Mr. Craig Mattheson, with the EPA Chemical Emergency Preparedness and Prevention Office, six speakers discussed critical infrastructure protection and homeland security, and the interconnectivity of these industries/sectors. A panel discussion including an audience question and answer period followed the presentations.

Security: The Business of Chemistry's Action

Dr. Marty Dubin, Security Team Leader for the American Chemistry Council (ACC), discussed security plans and communication tools. The ACC has over 160 member companies comprising more than 90 percent of the chemical industry in the United States involving diverse medical, telecommunications, and defense support. In October 2001, the ACC finalized guidelines for site and transportation security and used this as a foundation to add mandatory security care (site, cyber, and transportation) for member organizations.

This resulted in a New Responsible Care Security Code enacted by the ACC Board in June 2002. This includes an overall plan, actions, checks, and improvements as well as provisions for independent third party audit. Priorities were based on the attractiveness of the target and the severity of the attack based on attractiveness of the target. Four threat categories are assessed, including uncontrolled releases, theft, product contamination, and significant economic disruption. Any of the four categories of threats could cause offsite impacts.

The guidelines address physical, value chain, and cyber security. The physical security plan may include perimeter barriers, access control, inventory control, surveillance, and process control systems and equipment. Value chain security involves issues of communication, storage, and transit. In addition, guidance is provided for cyber security. An important aspect to consider is that no two chemical facilities are alike when evaluating security measures.

Facility response plans have been developed. Responses to security threats are color-coded, and are based on general and specific threats. A 24/7 hazardous material response capability is important, and the Federal Bureau of Investigation (FBI) built onto the existing 24/7 hazardous material response system to include a two-way response system with the DHS.

The intention of the New Responsible Care Security Code is to work very closely with the local communities and law enforcement. Performance and partnerships are extremely important within the chemical community. However, there are some challenges with jurisdiction. Different agencies/industries claim jurisdiction over areas of transport (e.g., United States Coast Guard [USCG], DOD, railways, etc.). The ACC is working very closely with the railroad industry on security issues. The industry has developed its own security plans post-9/11, and the Department of Transportation (DOT) is working to assure that the distribution chain is secure.

Homeland Security, Emergency Management, and a Water Utility

Mr. Paul Bennett, Director of Emergency Management at the New York City Department of Enviromental Protection (DEP), discussed issues related to the response of water utilities in the event of an attack, including both drinking water and wastewater responses. DEP is responsible for the water supply to New York City, and manages, operates, and protects the wastewater system. Thus, the DEP is both a regulator and a regulatee.

Emergency management is relatively new to the DEP. Prior to 1996, there was little coordination between agencies responding to an incident. In 1996, the Office of Emergency Management was moved from the New York Police Department to the Mayor's office, where aggressive interagency planning and response began.

The DEP plan is one of coordination with all interagency plans and resources available with a focus on protection of the water sector. There are currently partnerships between the DHS, DEP, and various other agencies. DEP provides pro-active training and is currently working with the United States Army Corps of Engineers in the development of a response protocol and early warning and detection.

The DEP is a first responder to many types of incidents including fires, building collapses, and raids, and is therefore familiar with the key people and concerns at various organizations. The DEP response to the WTC attack was well coordinated based on already developed plans and experience gained post-1996. Mr. Bennett discussed some of the activities of the DEP at the WTC site including the need to shut down broken water mains without interfering with firefighting efforts, debris blocking manhole access to underground utilities, coordination with firefighters to restore water supply operation in needed areas, and working with the FBI to deliver documents from the WTC from catchbasins and other wastewater system areas.

Emergency response issues associated with drinking water include:

- The need for fast and accurate detection
- An understanding of what the findings and results mean
- Clear response plans supported by local, state, and Federal agencies
- Clear decontamination protocols supported by local, state, and Federal agencies.

In addition, discharge of decontamination water is a major issue and the agencies involved must come to an agreement on the management of such wastes.

Emergency response issues associated with wastewater include the need to:

- Take clear action by wastewater treatment plants receiving runoff and discharge from hospitals

- Determine pre-chlorination effectiveness

- Consider the use of sewers to facilitate attacks

- Clear decontamination protocols.

A Public Utility Manager's View of Our World Post-9/11/2001

Mr. Michael Marcotte, with the District of Columbia (DC) Water and Sewer Authority, Mr. Gordon Smith, with Sandia National Laboratories (SNL), and Ms. Janet Pawlukiewicz, with the EPA Water Protection Task Force, provided a joint presentation on security issues, security approaches, and risk assessments in regard to protecting the water supply.

Mr. Marcotte, Deputy General Manager and Chief Engineer of the DC Water and Sewer Authority, explained that operation of the Blue Plains Water Treatment Facility, which serves 2,000,000 people daily, is governed by an 11 member regional board. This water treatment facility is highly visible and many municipal entities are on the "front line" as candidates for attack.

Chlorine disinfection products have historically been stored in large quantities onsite in rail cars with a master plan to change this by 2005. Alternative disinfectants to chlorine products have been investigated and, in December 2001, the last of the railcars holding the chlorine products was removed from the facility. These products are now stored in discrete one-ton containers as opposed to the 90-ton rail cars that previously sat by the Potomac River in plain view. As a result of these actions, methanol is now the most dangerous chemical stored onsite in large quantities and that the potential for disruption or sabatoge is low.

The wastewater collection system feeding to the treatment plant involves 1,800 miles of piping. This is a concern because large mains provide access that can be used to introduce biohazards, flammable materials, etc. Monitoring devices have been added to some pumping stations due to the serious concern about explosives and fires.

Despite all these actions to reduce threats or provide early warning of unsafe situations, additional security concerns remain as a result of an internal worker culture that "does not see" (i.e., does not report) suspicious items or activities.

Water security issues at the treatment facility include:

- Water pumping and storage—perimeter security (high), reliability/redundancy (high), and supervisory control, data acquisition, and related cyber issues (medium)

- Water distribution—remote quality monitoring (med/high) and hydrant/cross-connection control (medium)

- Culture/internal security (high)—training/personnel selection issues.

Security approaches at the treatment facility involve vulnerability analysis; fences, barriers, and walls; alarms, cameras, and sensors; and law enforcement involvement.

Mr. Gordon Smith, Manager of the Public Safety and Technologies Department at SNL, discussed the risk assessment process and its design and evaluation. SNL is a multi-program research and development laboratory under DOE. The counter-terrorism laboratory, run by Lockheed-Martin, is the lead laboratory for the physical security of nuclear sites that have materials or devices that could be fashioned into nuclear weapons.

Risk assessment in the context of this discussion is defined as a systematic approach to determining relative risk and is the backbone for vulnerability assessment methodologies. SNL developed a risk assessment methodology for chemical facilities and is currently developing a risk assessment methodology for communities as well. These are available for access by Federal agencies and by non-Federal persons (after signing certain agreements).

The risk assessment process involves the evaluation and consideration of the following:

- Planning to identify areas of vulnerability and support
- Quantifying consequences and effects
- Identifying targets using fault tree analysis
- Defining threats (highest threat now is the eco-terrorist), the likelihood of an attack, and a table or list of "most likely threats."

Design and evaluation of security procedures includes detection, security systems (protection), and risk comparison. The response force must be able to neutralize any adversary; this requires the ability to eliminate any threat. Security cameras detect but do not eliminate threats. In addition, security systems can be modeled to evaluate their effectiveness; many facilities have security systems that have a very low likelihood of stopping a terrorist attack. A risk comparison helps to assess the utility of upgrades in conjunction with changes in risk level to achieve the desired effectiveness.

Ms. Janet Pawlukiewicz, Director of the EPA Water Protection Task Force, discussed the EPA role in water security, accomplishments of the Water Protection Task Force, the EPA Homeland Security Strategic Plan, and the Public Health Security and Bio-terrorism Preparedness and Response Act of 2002 (hereafter referred to as the Bio-Terrorism Act).

Major areas of accomplishment related to the Homeland Security Strategic Plan include the development of tools, training, financing, research, technology development, building security, and information exchange. Funding includes $90 million in grants for vulnerability assessments and security planning among other areas. EPA also is developing protection strategies for large and small water systems, workshop and consultation services for medium-sized drinking water systems, emergency response guidance, and guidance on how to change security practices as the threat levels change. Research and technology development activities include the development of a comprehensive research plan for the entire water sector to be implemented by various agencies and organizations, and developing models through the ETV program to show the fate and transport through distribution systems and watersheds in the event of an incident. Funds have been allocated to table-top incident response exercises. Information exchange includes the

creation of a Water Information Sharing Analysis Center, coordination with interdependent infrastructure (e.g., electricity, transportation, telecommunications), and coordination with emergency responders, public health officials, and law enforcement.

The Bio-Terrorism Act covers approximately 9,000 systems within the United States and amends the Safe Drinking Water Act (SDWA). Requirements under this Act pertinent to water utilities include, the conduct of vulnerability assessments, development or revision of emergency response plans, and submission of certifications to the EPA. These activities are to be conducted in accordance with a phased schedule from March 2003 to June 2004 (depending on the size of the utility).

EPA is required to establish protocols for protecting the vulnerability information that is submitted. In addition, EPA is examining attack vulnerabilities and vulnerability assessment methodologies through collaborations and partnerships with a variety of agencies and organizations.

The Water Protection Task Force has a very detailed website (www.epa.gov/safewater/security) where additional information and updates on initiatives are provided. The activities being conducted by the Water Protection Task Force include multiple benefits such as emergency response plans and improvements in water quality as well as an emphasis on a security-oriented culture, which is very important. The "Four Ps" for Task Force activities are partnering, planning, protection, and practicing.

The EPA Safe Buildings Program

Dr. Nancy Adams, with the NHSRC, discussed the Safe Buildings Program and associated research activities. The Safe Building Program is one of three areas of emphasis at the NHSRC with the other two involving water security and rapid risk assessment. The Safe Buildings Program is focused on answering three questions:

- How to protect the occupants of built structures (schools, subways, etc.) and prevent purposeful contamination of these structures
- How to decontaminate built structures (the focus of the research)
- How to distribute this information to those who need it.

The four NHSRC sections are detection, containment, decontamination, and disposal. The NHSRC research approach involves:

- Separate consideration of detection, containment, decontamination, and disposal issues
- Selection of the most difficult to treat threat for initial decontamination studies
- Grouping materials as aerosols or gases for studies on prevention and containment
- Grouping gases by chemical and physical characteristics for containment.

Detection involves the testing and verification of existing detection devices (via the ETV program), development of new devices or sampling and analysis methods, and the design of

sampling and detection networks. Current detection activities include surface sampling for spores and the use of four multi-analyte detection systems.

Containment involves HVAC improvements, development of gas and particle filters, specifications for safe havens, retrofit improvements, and economic considerations. Current containment activities include modeling indoor releases and emergency responses, and developing a building owner's guide.

Decontamination efforts involve efficacy testing, safety issues, cost issues, and regulatory support to OPP. Current decontamination activities include technology evaluations by the Army's Edgewood Chemical Biological Center (ECBC), the EPA ETV program, and the EPA Small Business Innovation Research (SBIR) projects.

Disposal efforts involve testing of incineration and landfill application methods, selection of appropriate disposal facilities, and assessment of residuals. Current disposal activities include carpet incineration and workshops with waste managers.

Panel Discussion/Questions and Answers

The speakers had an opportunity to participate in a brief panel discussion drawing on questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) the use of plastic sheeting and duct tape; (2) suggestions for working out the differences between methodologies and actual decontamination efforts; (3) the needs of onsite responders; (4) background concentration determinations; (5) coordination of state, local, and Federal agencies in the development of guidelines; (6) public access to information regarding water and air pathogens; and, (7) the attack of critical facilities.

BioWatch – Nationwide Early Detection of Airborne Biological Agents

Mr. Thomas Coda, the lead for Homeland Security Programs in OAQPS, discussed the development and implementation of the Bio-Watch surveillance network for early detection. Bio-Watch involves the rapid recognition of releases of biological agents before the on-set of illness, and measures the extent of the releases.

The concept began with a system called BASIS, which was designed for the Salt Lake City Olympic Games. After the September 11th terrorist attacks, EPA met with other agencies to determine how this system could be deployed nationwide.

The Bio-Watch system consists of over 3,000 monitoring systems in highly populated area across the United States. Locations for monitors were chosen based on the same kind of meteorological modeling used to select other types of monitoring sites. The structure of the system is as follows:

- DOE has the responsibility for selectivity, technical support, and acceptability of the equipment

- EPA has the responsibility for sampling

- CDC has the responsibilities of performing analyses and data management.

Mobile training teams sent out across the Nation set up the monitors and provided hands-on training to local, state, and other environmental personnel. The monitors consist of 47-millimeter filter units that draw high volumes of air over them. The filter units are collected every 24 hours and taken to CDC, where a series of tiered assays are run. These laboratory assays take approximately 6 to 8 hours to run with results returned in as little as 36 hours. This system is used for the types of releases that cover large areas and has been validated using live agents. Initial samples were used to determine background levels.

Use of this system could result in much quicker isolations of areas and early treatment because the exposure time would be reduced. The current status of the Bio-Watch system is that is has a robust capability deployed and operating across the United States. The system is providing information back to the local communities who are responsible for developing a consequence management plan. The CDC provided a template for such a plan, but because every city is unique, it is left to the up to the cities to develop their own plans.

The Bio-Watch system is not perfect, but it is an appropriate technology for what is trying to be accomplished. The system will be reconfigured as necessary based on lessons learned and table-top exercises.

World Trade Center: Lessons Learned, and Personnel Protection and Training

Session moderator, Mr. Larry Reed, with NIEHS, spoke briefly about some of the lessons learned in the aftermath of the WTC attack regarding collaborations, after which five additional speakers discussed worker protection issues and the importance of immediate response collaborations. A panel discussion including an audience question and answer period followed the presentations.

World Trade Center Lessons Learned and the Interagency Collaboration

Mr. Larry Reed, with NIEHS, began this session with a discussion of some of the lessons learned regarding collaboration in the context of the responses to the WTC attacks. Federal agencies involved in the aftermath of the September 11th terrorist attacks included EPA, DHHS, the Agency for Toxic Substances and Disease Registry (ATSDR), NIEHS, NIOSH, the Occupational Safety and Health Administration (OSHA), the Federal Emergency Management Agency (FEMA), and their state and city government counterparts.

Difficulties encountered with interagency collaboration stem from differing agency cultures, communication methods, stakeholders, and missions as well as agency "tunnel vision." The benefits of collaboration include leveraged resources, faster transfer of knowledge, and more supportive stakeholders through consistent communications (i.e., the public received the same information from all agencies involved). An Interagency Task Force was established to assist in

data analysis and interpretation. The Task Force was led by representatives from EPA, ATSDR, and OSHA, and shared information as well as database and website development. Other areas for collaboration include evaluation of longer-term impacts, assessment of health impacts, and first responder training. Of final note was that all disaster response should be conducted in compliance with the requirements of OSHA under 29 CFR 1910.120.

9/11 Lessons Learned for Worker Protection

Mr. Joseph Hughes, Jr., with NIEHS and Mr. Bruce Lippy, with the National Clearinghouse for Worker Safety and Health Training, discussed the conditions and problems encountered at the WTC site with regard to worker safety and training.

Mr. Joseph Hughes, Jr., Director of the NIEHS Worker Education and Training Program, noted that being onsite at the WTC presented an opportunity to be in a position to examine site safety and health plans, and to be able to examine the use of PPE and environmental monitoring practices. An onsite safety and health training program was put together for approximately 4,000 workers. Since the WTC experience, NIEHS has conducted workshops regarding lessons learned from that disaster and workshops focus and preparedness. The NIEHS Worker Education and Training Program was also involved in training the anthrax cleanup crews who worked onsite at the Hart Building and the Brentwood Post Office.

Mr. Bruce Lippy, with the National Clearinghouse for Worker Safety and Training, discussed worker conditions at the WTC. Arriving about one week after the WTC collapse, his focus was to ensure protection of equipment operators. OSHA distributed over 120,000 respirators yet only about 20 percent of the personnel wore the respirators, and there was no appreciable amount of respirator fit testing until about 36 days later. This pointed to the need for skilled support personnel.

Other lessons learned included the need to:

- Improve command, control, communications, and coordination during disaster response
- Provide better protection of support personnel at disaster response sites
- Provide pre-incident training
- Establish effective injury and illness surveillance and exposure monitoring at disaster response sites.

In addition, training input for disaster response needs to be continuous.

Immediate Response and Collaboration: EPA Region Perspective

Dr. Mark Maddaloni, with EPA Region 2, discussed the physical and chemical challenges encountered after the WTC attack.

The initial hurdles after response were the physical challenges such as the facility building being closed for three weeks following September 11, 2001. There were also staffing constraints, including the availability of key personnel. Re-location of people to Edison, New Jersey was difficult and chaotic. In addition, communication was very difficult as a result of limited computer access and telephone service.

The chemical challenges encountered included:

- Management of real-time data, QA/QC, limited laboratory capacity, and data interpretion
- Difficulty in assessing acute toxicity criteria
- Ability to address chemical mixtures
- Limited sampling data and experience with certain types of sampling such as particulate matter (PM)
- Anticipated exposure duration since tens of thousands of people were allowed to come within one block of a disaster area.

Solutions to these challenges included the use of cell phones, the use of libraries, reaching out to sister agencies, and conference calls to communicate results.

Immediate Response and Collaboration: ATSDR Perspective

Mr. Sven Rodenbeck, Section Chief for the Superfund Site Assessment Branch at ATSDR, discussed the difficulties encountered in conducting sampling at the WTC. Multiple national response teams were deployed, and at the four first aid stations positioned around the WTC site, over 9,500 responders were seen and/or treated. There were questions about what was inside of the buildings (especially the residential buildings) that was now being blown around. While there was limited residential sampling conducted, a limited investigation was performed to assess the need for follow-up sampling. A total of 34 buildings were sampled in November and December 2001.

ATSDR assisted with this sampling effort, which was focused on the main constituents of the buildings such as concrete, wallboard minerals, asbestos, and fibers. There were higher levels of mineral and fibrous materials in the settled material, and it was estimated that there would be a higher risk of lung cancer as a result of exposure if the exposure concentrations remained the same. This was not the case since the site was cleaned up.

Current directions for ATSDR in this process at the present time involves the WTC Exposure Registry. This registry will be used to compare exposure with background conditions and also will follow-up on mental health issues. In addition, a Rapid Response Registry will support response to future terrorist events to identify those that may have been exposed in an attack within hours of the event. This will also provide a mechanism for later follow up on health and mental effects.

Longer Term Response and Collaboration: NIEHS Perspective

Dr. Claudia Thompson, Program Administrator for the NIEHS Superfund Basic Research Program, discussed NIEHS WTC research activities. Investigators were at the WTC site very soon after the attack, and within the first few months afterwards were collecting onsite dust samples and beginning studies. This involved a collaborative effort on the part of different universities, the EPA, and state and local Departments of Health.

WTC-related activities involve exposure, modeling, and health effects (e.g., respiratory effects, pregnancy outcomes, and developmental effects). Examples of collaborative efforts include the Public WTC Exposure Database, WTC brochures, community forums, publications, and joint scientific planning meetings. Also, publications of the activities at the WTC site have begun to be released.

NIEHS received an additional $4.5 million for research. This includes future opportunities for collaboration on homeland security research, including:

- Developing a program for public health preparedness and physician and nurse training on environmental medicine to include the creation of preparedness teams and development of training courses

- Developing a basic and applied research program in chemical terrorism as it impacts human health and the environment.

Evaluation of Health Effects of Cleanup and Recovery Workers at the World Trade Center Disaster Site

Dr. Alison Geyh, Assistant Professor in the School of Public Health at Johns Hopkins University, discussed the partnerships that aided in the evaluation of health effects resulting from exposure to the WTC site. The initial exposure assessment led to many questions, which led in turn to a very large study being conducted on those individuals involved in the WTC cleanup efforts. This study, funded by the NIEHS since October 2002, is being conducted through strong partnerships with New York and Columbia Universities, labor unions (teamsters, engineers, laborers international), state government agencies such as the New York City Departments of Health and Sanitation, the EPA, and health care facilities.

Monitoring stations were placed around the WTC site and on people to generate a data set that includes data from right after the terrorist attack through several months later. This database will be made available soon and will include data from the partner organizations. Health assessments of cleanup and recovery workers are being conducted by Johns Hopkins School of Public Health and Columbia University.

World Trade Center Assessment Report

Mr. Herman Gibb, with the National Center for Exposure Assessment (NCEA), discussed the WTC Assessment Report. This report was compiled at the request of EPA Region 2, which has responsibility for New York City, and was reviewed and released on the EPA website in

December 2002. The WTC Assessment Report focuses on outside measurements of exposure with some discussion of indoor exposure, general population exposure with some discussion on worker exposure, and relationships to air concentration benchmarks. Data sources include the EPA website, EPA's national health and environmental effects research, and background concentrations among others.

There were three principle findings of the report. First, persons exposed to high levels of ambient PM and its compounds are at risk for immediate acute (and possibly chronic) respiratory and other types of symptoms such as cardiovascular. Second, some health effects cannot be determined effectively for the September 12-23, 2001 time period because some of the contaminants were not measured until September 23, 2001. Third, the surrounding community is unlikely to suffer short- or long-term effects, except for the first few days after the attack when the concentrations were at their highest.

Lessons learned from this assessment include:

- Health guidance for acute and sub-chronic exposures is needed
- Beginning sampling as early as possible after an event is important
- Earlier and more extensive indoor sampling is helpful
- Monitoring objectives need to be clearly defined
- Measurement techniques need to be identified (for example, dioxin).

Another lesson learned is that risk communication is a major issue for such as response. Comments were made that it would have been helpful for the government to speak in one voice as opposed to hearing different agencies saying different things.

Panel Discussion/Questions and Answers

The speakers had an opportunity to participate in a brief panel discussion drawing on questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) the examination of brominated contaminants; (2) the compilation of a responder/worker competency list; (3) determination of adequate training time; (4) the use of privately collected data; (5) a process for compiling data and other information from government agencies; and (6) the potential to normalize data.

Preparing for Bioterrorism Threats in Water

Following opening remarks by Dr. Jafrul Hasan, with the Office of Science and Technology, and Mr. Chris Zarba, with National Center for Environmental Research (NCER), five speakers addressed security and detection technology research as they relate to bioterrorism threats in water. A panel discussion including an audience question and answer period followed the presentations.

Dr. Jafrul Hasan, with the Office of Science and Technology in the Office of Water, provided a brief session overview and noted the EPA contributions to homeland security. Of particular note

is the need to improve analytical monitoring and detection in drinking water systems as well as the need to define existing technologies to support this. Gaps and opportunities exist such as addressing bacteria, viruses, and toxins with the potential challenge of facing a disinfectant-resistant virus introduced into the water supply.

Mr. Chris Zarba, with NCER, provided a perspective on biological effects including the need to draw not only on in-house expertise but to also reach outside of EPA. The anthrax scare of 2001 alone involved four contaminated letters, potentially three other letters never recovered, 23 contaminated locations in the United States, over 30,000 samples taken in the Hart Senate Office Building alone, over 30 tons of waste generated from decontamination that had to be managed as hazardous waste, about $130 million spent to cleanup just the Brentwood Post Office, and almost $1 billion spent so far for all anthrax site cleanups. Thus, there are good reasons for biological threats to be high on the list of threat considerations.

NHSRC's Water Security Research and Technical Support Program

Mr. Jonathan Herrmann, with the NHSRC, discussed the operating principles and the scope of the Water Security Research and Technical Support Program. The goal of this research program is to provide, within three years, appropriate, affordable, reliable, tested, and effective technologies and guidance for preparedness, detection, containment, decontamination, and risk of chemical and biological attacks on buildings and on water systems. The key principles of this research program are short-term, high-intensity, applied efforts; an understanding of and focus on user needs; targeting key knowledge gaps; producing high quality, useful products quickly; and partnering with ORD, EPA, other agencies, and the private sector. The overall homeland security strategy involves critical infrastructure protection, preparedness, response, recovery, communication, and information as well as protection of EPA personnel and infrastructure.

The scope of the Water Security and Technical Support Research Program encompasses physical threats as well as biological, chemical, and radiological contaminants in drinking water and wastewater systems. Facilities available support this research include the Biological Containment Facility (a level-3 facility), a small drinking water pilot plant, the Test and Evaluation Facility in Cincinnati, Ohio, and a water distribution simulation facility.

The overall approach of this research program involves identification, detection, containment, treatment, decontamination, disposal, risk, and information sharing. An Action Plan has been developed for this research program and is 5 chapters long, with chapter three being heart of the plan and focused on drinking water. The Action Plan also addresses physical and cyber protection as well as wastewater systems, rapid risk assessment, and technology verification.

The three areas of emphasis in the rapid risk assessment approach are rapid risk assessment following an event, risk assessment of defined threat scenarios, and long-term risk assessment research. The roles of the rapid risk assessment are to help prepare responders to address health issues related to water threats and to participate in the response with expert risk assessment information.

Technology verification activities in terms of water security include monitoring and detection (e.g., cyanide and toxicity), point of use treatment (such as reverse osmosis filtration and

ultraviolet irradiation), drinking water system decontamination, and treatment of decontamination waters.

Key collaborators in the supporting this research program include:

- Office of Water, OPPTS, Office of Radiation and Indoor Air, and OSWER
- EPA Regional Offices
- United States Army's Edgewood Chemical and Biological Center
- Food and Drug Administration's Forensic Chemistry Center
- Air Force Research Laboratory
- Metropolitan Water District of Southern California
- United States Geological Survey (USGS)
- CDC
- United States Army Corps of Engineers
- DOE's National Laboratories
- National Science Foundation (NSF).

Ms. Grace Robiou, with the EPA Water Protection Task Force, discussed the role of the Water Protection Task Force in water infrastructure security, which includes:

- Assisting the water sector in understanding the threats to water security

- Helping utilities assess their vulnerabilities to possible attack

- Providing tools based on the best scientific information and technologies to assess risk and respond in the event that an incident occurs.

The types of threats that are of concern to the Water Protection Task Force include biological, chemical, radiological attacks; physical destruction or damage; cyber attack; and interruption of interdependent activities such as fire suppression, electricity, and/or transportation.

The three projects highlighted for consideration are agent prioritization, the development of a response protocol for contamination threats to drinking water, and the assessment of laboratory capabilities. The objectives for agent prioritization are to conduct technical activities in support the development of procedures for analysis of unknowns in water and the water security research plan. Agents posing a threat to water include pathogens (e.g., protozoa, bacteria, viruses), biotoxins (e.g., plants, algae, bacteria), chemicals (e.g., pesticides), and radionuclides (sealed sources).

The objectives for developing a response protocol for contamination threats to drinking water are to provide a framework of considerations and procedures to guide the response to a water treatment threat, and to focus on the question of what a utility, laboratory, or emergency responders need to consider in preparation for an event.

The objectives for the assessment of laboratory capabilities are to identify laboratories able to implement analytical response protocols for unknown contaminants in water and laboratories with basic capabilities to support water utilities in an emergency.

Potential Technologies for Detection of Biological Threats in Water Supplies

Dr. John Ezzell, a Senior Scientist with the United States Army Medical Research Institute of Infectious Diseases, discussed various technologies used in the detection of biological threat agents in water. The currently recognized biological warfare agents were selected many years ago because of the ability of these agents to be stabilized for weaponization. These agents are infectious as aerosols and can be produced in mass quantities. "Fear" is the key word in bioterrorism.

Waterborne infectious diseases (acquired by ingestion) include viruses and bacteria such as *salmonella*, *e. coli*, and *cryptosporidium*. It is very difficult to monitor for a broad range of bacteria and small facilities do not have the manpower, equipment, educated individuals, etc., to monitor any better than they are currently doing.

When samples are in the fluid state, they can be moved into other types of technology such as polymerase chain reaction, immunoassays, and cultures. Automated sample processing systems, such as GeneXpert, are useful, and instrumentation currently being used by the CDC includes the Threshold and Bio Threat Alert Test Strip. Immunological assays that may be applied to water testing for biological threats include dried-down chemistries, broad dynamic range, and 30-minute assays. Other tests that may be applied include enzyme-linked immunosorbent assay and fluorescent antibody assay.

In addition, sentinal types of approaches may be necessary. For example, if a change in pH results in a change in a protein, this may serve as an indicator to identify the need for further testing. Research efforts need to look for such common denominators.

"Early Warning Monitoring" and Sensor Technology Development

Ms. Janet Jensen, Project Manager for the Joint Service Agent Water Monitor (JSAWM) Program with the United States Army Soldier and Biological Chemical Command, discussed the JSAWM program, which was designed to develop advanced capabilities to detect, identify, and quantify chemical and biological contaminants in source treated and distributed consumer water supplies. Research program components include sensor technology, new models, working with USGS in surface and ground waters, and working with EPA in product waters.

The goal is for rapid results and the ability to work in different kinds of waters. The program involves the systems concept with technological modules that are "plug and play" as well as easy to update. Currently, there is no single commercially available product that meets all of these needs.

The program plan is currently in the testing phase for biological agents, and candidate technologies are being sought. The program plan has successfully passed peer review and is

scientifically sound. Upcoming efforts include sensor simulation, proof-of-concept for reagentless detection, and development of a database of processes entitled Tech Watch.

Detection of Biological Agents in Water

Dr. Alan Lindquist, Technical Lead for Detection of Contaminants of Concern in the Safe Buildings and Safe Water Programs at NHSRC, discussed the detection of agents of biological terrorism in water and an approach for moving the science forward.

Currently, there is no written approach for detection of biological agents in water and protocols have not been tested. The analytical technology currently available includes concentration followed by use of modified classical models, concentration followed by use of molecular methods (polymerase chain reaction-based), antibody tests, and black boxes.

What should be available includes:

- Written protocols that cover all aspects of detection from sampling to the interpretation of results
- All pertinent information, including but not limited to supplies and suppliers, standards, and training requirements
- Appropriate quality control
- Protocols that have been tested in multiple laboratories using realistic challenges.

Moving the science forward involves the development of a draft protocol that undergoes peer review and laboratory testing. The protocol should address such topics as large volume sampling, field concentration, and laboratory testing for bacteria, viruses, and protozoa of interest, including both presumptive molecular testing and classical methods.

There are a number of advantages and disadvantages associated with various types of approaches, such as:

- Rapid field screening cannot yet be recommended because it does not include analytes specific for water.
- Molecular assays give presumptive results, yet benefits of this technique are the potential for automation and specificity to the organisms of interest. Weaknesses include viability and unknown sensitivity.
- Classic assay techniques consist of cultures, antibody detection for protozoa, and cell cultures for viruses. Advantages include the availability of validated protocols, which are generally "reference" methods. Disadvantages include sensitivity, the potential for low specificity, long-term requirements, and assay methods are not available for some organisms.

Immediate actions and future directions include:

- Drafting, testing, laboratory validation, peer review, and dissemination of the draft protocol
- Evaluating commercial technologies
- Research to fill weak areas of the protocol
- Research on alternative methods including rapid assays, diffuse monitoring systems, and biologically based monitoring.

Panel Discussion/Questions and Answers

The speakers had an opportunity to participate in a brief panel discussion drawing on questions from the audience.

A brief question and answer period addressed a range of topics. These included the availability of information on the ETV website, and concerns about mailing tests.

Section IV: Moving Science Into Action

Tuesday and Wednesday, May 6-7, 2003

The purpose of this session on the second and third days of the meting was to focus on ongoing projects, activities, and initiatives of current or anticipated databases, models, and decision support tools on a national, regional, state, local, and tribal level. This included several pilot projects, partnerships, and communication efforts supported by EPA as well as pertinent needs and uses of scientific data to assess environmental conditions and human health risks. Each session included a panel discussion and opportunities to respond to audience questions that provided additional information and insight on a variety of emerging technology topics.

Dr. Betsy Smith, with the National Environmental Research Laboratory (NERL), led a session presenting the Regional Vulnerability Assessment (ReVA) tool and its applications to environmental analysis and decisionmaking. Presentations included an overview of the ReVA tool, partnerships in ReVA development, the functions of the web-based tool, an overview of a regional and intergovernmental Sustainable Environment for Quality of Life (SEQL) project, and examples of ReVA application at the state level focusing on initiatives underway in the State of Maryland.

Mr. Gilberto Alvarez, with EPA Region 5, led a session addressing scientific projects involving partnerships with state and local governments to provide scientific insight to support decisionmaking. Presentations included determinations of water quality from salmon migration in the San Francisco Bay area, conducting integrated environmental planning to address urbanization and land use expansion efforts in the Central North Carolina area, and efforts of the Michigan Environmental Science Board (MESB) in protecting children's health.

Dr. Michael McDonald, Director of the Environmental Monitoring and Assessment Program (EMAP), led a two-part session providing highlights of EMAP and its application. Presentations included an overview of EMAP and the EMAP Western Pilot program, EMAP capabilities and uses in state programs featuring examples from California, EMAP uses by the Nez Perce tribe, an overview of the National Coastal Assessment Program, application of EMAP to the Southern California Coastal Water Research Program (SCCWRP), the role of the National Coastal Assessment Program in supporting South Carolina Estuarine and Coastal Assessment Program activities, and the application of EMAP and REMAP to CWA compliance initiatives within EPA Region 2.

Mr. Thomas Baugh, with EPA Region 4, led a session addressing diverse scientific initiatives and other tribal activities to understand and address environmental issues. Presentations included investigations into pesticide use and exposure at the Big Valley Rancheria, tribal partnerships to investigate and minimize exposure to environmental contaminants from military

sites and other sources at the St. Lawrence Island in Alaska, and Swinomish tribal initiatives to address contamination of shellfish, a critical subsistence food item.

Ms. Pamela Russell and Mr. Mike Flynn, with the EPA Office of Environmental Information, led a session addressing diverse Federal/state partnerships for data acquisition and analysis, the use of data collected from the Toxics Release Inventory (TRI), and web-based tools for environmental data analysis to determine environmental and human health impacts. Presentations included diverse applications of data collected for the Toxics Release Inventory (TRI) program, a Maryland program to integrate state- and county-level stream monitoring programs, an evaluation of the effects of urban growth on environmental health, and a mapping tool to visually depict trends in human health and environmental conditions.

In another session, five speakers provided overviews of several regional projects to determine and protect the environmental conditions of ecosystems. Presentations included the application of geospatial tools in EPA Region 5 characterize and rank ecosystem quality, synoptic modeling in EPA Region 7 to prioritize and rank ecosystems, a partnership for ecosystem study and protection in EPA Region 4, and the findings and benefits of the Mid-Atlantic Highlands Action Program.

Dr. John Bing-Canar, with EPA Region V, led a session addressing tools used in a contaminated sediments study supporting decisionmaking for remediation. Presentations addressed the contaminated sediments study and the approaches and tools used for site characterization, initial sampling design, spatial estimation of contamination, and decision analysis.

Regional Vulnerability Assessment: Improving Environmental Decisionmaking Through Client Partnerships

Following opening remarks by Dr. Betsy Smith, with NERL, four speakers addressed the ReVA project, its web-based analysis tool, and applications of the tool to support scientifically-based decisionmaking. A panel discussion including an audience question and answer period followed the presentations.

Dr. Betsy Smith, with NERL, provided opening remarks including an overview of ReVA, its features, and capabilities as a web-based tool available to ORD's client partners. Dr. Smith then introduced the other speakers in this session.

ReVA's Client Partnerships: Improving Environmental Decisionmaking Through Applied Research

NERL scientist, Dr. Betsy Smith, described the ReVA project and its benefits to client partners. This project receives funding from ORD and is a sister program to ORD's EMAP. ReVA uses monitoring data from EMAP, as well as other programs, to support risk management actions. ReVA is being utilized in cross-agency laboratories and interagency programs, with support provided by ORD and its partners, including the USGS, United States Forest Service, and the Tennessee Valley Authority.

ReVA is an applied research program designed as a flexible framework for use and fine-tuning by various national, regional, and local decisionmakers responsible for building, sustaining, and improving their communities while protecting the environment and human health. Current client partners of the ReVA program include the Centralina Council of Governments, EPA Region 3 Air Protection Division, EPA Region 4 Air Toxics Assessment and Implementation Section, the Pennsylvania DEP, the Maryland Department of Natural Resources, Baltimore County (in Maryland), and the Canaan Valley Institute.

ReVA was initiated for the Mid-Atlantic region of the United States. Government agencies and other organizations in the Mid-Atlantic region have historically maintained various types of data as a result of many research efforts and environmental initiatives. A primary feature of ReVA is the ability to manipulate and handle varied types of data, therefore, the Mid-Atlantic region provided as a great basis for project initiation. ORD has completed its first assessment of ReVA in the Mid-Atlantic region and will soon begin a second phase of assessment in another region.

ReVA offers a web-based tool and modeling system to help decisionmakers protect the environment and the human health of their communities by:

- Estimating conditions and exposures for every point on the map, including watersheds
- Identifying current and future vulnerabilities by providing ecological forecasting with the use of a modeling system

- Enabling trade-off analyses through "what if" scenarios and evaluating different alternatives with the use of a modeling system

- Linking environmental health with economic and human health for a truly integrated assessment

- Synthesizing data to determine vulnerabilities, manage like units, and track the completion of program tasks and goals.

Although EPA continues to cleanup historic problems to allow for a healthy environment, ORD has seen declines in biological populations despite compliance with environmental regulations set to strengthen biological populations. Such declines could be the result of population growth, changes in land use for mining and timber activities, extraction of rich resources, an increase in pollutants, and the invasion of exotic species, as well as the cumulative and aggregate impacts from all of these influences. ReVA enables users to evaluate current problems, such as these, and to project future problems using regional modeling.

ReVA also can help to project land use changes, which are the result of economic influences, planned roads and developments, and rural and urban transformations. These same land use changes that can benefit a community may also negatively affect pollution, pests and pathogens in forests, conservation of native biodiversity, flood risk, nonpoint source pollution, urban sprawl, drinking water quality, and economic opportunities. When evaluating problems and land use changes, the ReVA program considers air deposition of pollutants, such as sulfates, nitrates, ozone, and PM; sediment loadings; agricultural chemicals used across the region; total maximum daily loadings; and forest health and biodiversity.

As an example, the ReVA program can help leaders in the Highlands area of West Virginia to make decisions on economic priorities while considering the environmental effects of increasing coal mines and chip mills in the regional area. The Highlands of West Virginia is known as a globally unique area because of the abundant intact, deciduous, temperate forest, and therefore, a generous habitat for large, migratory species. The Highlands area also has one of the highest unemployment rates within the Mid-Atlantic region, and is targeted by resource extraction industries because of its coal mining and hardwood forests areas. ReVA can provide decisionmakers opting for an increase in resource extraction activities with information on the resulting potential impacts on native biodiversity, water quality, and overall quality of life as well as employment rate increases and economic benefits.

ReVA provides a way to integrate and combine data to facilitate and understand multiple criteria that need to be considered in making regional decisions. Decisionmakers can look at scientific data, but also can consider other aspects such as stakeholders, water quality, effects on employment rates, changes in the environment, politics, and economics. With its web-based integration tool, ReVA turns spatial data into easy-to-understand and useful information for decisionmakers, and enables them to integrate criteria and prioritize using selectable subgroups of data.

ReVA's Web-Based Application: A Tool for Regional, State, and Local Decisionmakers

President of the Waratah Corporation, Dr. Michael O'Connell, demonstrated the capabilities of ReVA's web-based integration tool that extracts information from spatial data. ReVA extracts a signal from noise in the background of spatial data to determine land plots, watersheds, rivers and lakes, and any other geographical area to be considered.

Users of the ReVA web tool can specify map types to be used in the information gathering process, including maps that depict water and air influences, communities and residents of geographical areas, and terrestrial categories. These maps also can be manipulated to create "weighted maps" that are more influenced by certain indicators than some others. The spatial map types selected by the user are accompanied by a histogram to show additional information (e.g., number of watersheds).

The ReVA web tool also has on-line diagnostics to aid users in looking at distributions in more detail and in integrating data. Users also are able to create a radar plot for data.

The Sustainable Environment for Quality of Life Program: A Partnership Between EPA ORD and OAQPS, and State and Local Governments

Project Manager with the Centralina Council of Governments, Ms. Rebecca Yarbrough, described the SEQL project and its benefits to politicians, land builders, and other leaders in the Charlotte, North Carolina region. The SEQL project is a team-sponsored initiative between EPA ORD, the Centralina Council of Governments in Charlotte, North Carolina, and the surrounding areas. Program partners also include EPA OAQPS and the North Carolina Department of Health and Environmental Control.

The SEQL project was initiated when the Charlotte, North Carolina Mayor Pat McCrory and other elected officials considered ways to improve the environment in particular regions of the Charlotte area. Through the SEQL project, leaders and elected officials plan to make a difference in the quality of life in the Charlotte region; influence intergovernmental collaboration and cooperation; promote involvement, innovation, and change; and implement regionally-endorsed environmental initiatives, such as improvements in air and water quality as well as smart (or sustainable) growth. SEQL project team members also are hopeful to institutionalize environmental considerations in local and regional decisionmaking.

In the past, no one considered how land use changes, economic growth, and urbanization within one area impacted another area. Also, as communities grow closer through expansion, there are more adverse impacts on air and water quality, human health, forests, watersheds, rivers and lakes, and other environmental areas of concern. The SEQL project addresses several action items, including environmental education, tree planting ordinances, smoking vehicle enforcement, stream buffering, retrofitting public vehicles with less-polluting energy sources, open burning, and ozone awareness. These goals can be achieved by developing and distributing educational tools (e.g., toolboxes and how-to documents), providing regional and peer support in implementation, engaging in governmental and non-governmental partners in developing consensus solutions, and establishing a database that permits measuring and reporting successes.

Toolboxes and how-to documents are designed as educational items that explain the goals of the SEQL project, benefits and costs, and ordinances. The toolboxes and how-to documents also include required forms for land use and environmental restoration activities, and provide users with simple step-by-step instructions on how to address action items and goals of the SEQL project.

Science plays an important role in the SEQL project, and ReVA provides the body of evidence that is needed to defend decisions on future land use changes, smart growth, and environmental restoration activities. For example, a politician is asked to develop land in an area near a watershed, and the new residential community will include one-acre lots. The same politician also has been asked to approve a budget that includes an extra $0.12 per gallon to change the fuel use of public school buses to ultra-low diesel fuel gasoline, which allows for improvements in transportation emissions. The SEQL project, along with ReVA, can help with these decisions by providing the politician with scientific data to compare the environmental benefits of an ultra-low diesel fuel gasoline and related costs with the effects of land use changes. ReVA is a framework for looking at cumulative impacts and alternative growth scenarios and can permit leaders to analyze cumulative impacts on a multi-county basis.

ReVA's Partnership with the Maryland Department of Natural Resources: Opportunities to Optimize the Future

Director of the Maryland Department of Natural Resources (DNR), Watershed Management and Analysis Division, Mr. William Jenkins, described specific State programs and activities that can benefit from ReVA and its web-based tools. Maryland is a relatively small state, with 6.2 million acres. Approximately 70 percent of the State consists of privately owned farmland and forests, and 18.5 percent is developed. However, statistics depict a future increase in development involving 15,000 acres per year for residential and commercial land uses.

With the increased land use, the Maryland DNR hopes to increase the effectiveness and efficiency of their enhancement and restoration activities, and ReVA can help to achieve these objectives by providing the best technology and technically sound information. ReVA also enables Maryland DNR scientists to create desktop and web-based decision support tools, including automatic geographic information system (GIS)-based analytical functions, simplified user interfaces, and automatic report generation capabilities. ReVA enables Maryland DNR researchers to analyze all scenarios in order to address thresholds, vulnerable areas, data sensitivity, and use of specific indicators for different thresholds. ReVA also enables the Maryland DNR to focus on emerging management issues and the future impacts of exotic and invasive species.

ReVA can help the Maryland DNR consider how much watershed restoration or protection is sufficient, based on the current conditions and future threats, as well as to prioritize watersheds requiring immediate attention. In 1996, the Maryland DNR developed watershed-based indicators to assess regional watersheds from environmental and socioeconomic indicators of:

- Resource conditions—defined as one or more aspects of existing environmental quality

- Landscape stress (or vulnerability)—defined as the extent or magnitude of human-induced activities

- Programmatic response—defined as the extent or effectiveness of programmatic activities.

The Maryland DNR used a comparative watershed assessment program based on a GIS (ArcView) application in order to combine these indicators and establish threshold values to produce watershed aggregations for each priority watershed. The ArcView application enabled researchers to combine and assign weights to indicators, but was unable to provide a statistical analysis and could not be accessed via an internal network or web browser. Use of ReVA will help to address these drawbacks.

The Maryland DNR also initiated a GreenPrint Program to preserve the State's green infrastructure and to safeguard the State's most valuable ecological lands. With the green infrastructure assessment program, Maryland DNR created a funding mechanism to provide support to protect ecological components using a landscape model, but was limited to a coarse-scale analysis, an incomplete range of ecosystem elements and features with GIS data. The GreenPrint Program focused on hubs (large contiguous blocks of natural resource lands) and corridors (ecological routes between hubs). ReVA can help to evolve the model to allow for analyses at various scales with combined and weighted parameters. ReVA also can help the Maryland DNR to combine the current watershed and landscape assessment tools.

The Maryland DNR also hopes to use ReVA applications to enhance the Surf Your Watershed project, a cooperative effort with the Maryland Department of the Environment. Surf Your Watershed is a tool to catalog important environmental, socioeconomic, and programmatic information on a watershed basis. The catalog provides a list of selected watershed indicators for Maryland and allows the user to select an indicator in order to view a map that represents the data.

In working with the ReVA project, the Maryland DNR hopes to:

- Identify and develop analytical tools and indicators necessary to interpret stressor-receptor relationships at different spatial scales

- Develop scientifically defensible methods for assessing watershed and landscape sensitivity, condition and function, and threshold values for indicators at different spatial scales

- Create the capability to make analytical tools and data available to the resource decisionmakers and the public via the Internet

- Enhance DNR's capability to integrate economic and ecological information through the creation of decision support systems

- Establish a long-term working relationship with other regional, state, and national environmental protection programs.

Panel Discussion/Questions and Answers

The speakers had an opportunity to participate in a brief panel discussion drawing on questions from the audience.

A brief panel discussion addressed a range of topics. These included: (1) approaches for outreaching and educating students and the public, (2) allowing easy access to the ReVA web tool so that universities and smaller organizations can use the tool, (3) including either qualitative or quantitative predictions as well as statistical methods, (4) data quality and data quality guidelines, and (5) utilizing the ReVA web tool to enforce or influence environmental regulations, specifically total maximum daily loadings of pollutants in watersheds and waterways.

Partnership With State and Local Government

Following opening remarks by Mr. Gilberto Alvarez, with EPA Region 5, three speakers presented ongoing projects that are prime examples of partnerships between EPA, state or regional agencies, and other organizations. A panel discussion including an audience question and answer period followed the presentations.

Mr. Gilberto Alvarez of EPA's Region V provided the opening remarks for this session, and provided an overview of the three examples of successful regional and state projects presented in this session. Mr. Alvarez then introduced other speakers in this session.

Delta Cross Channel Gate Operation on Water Quality and Migration of Juvenile and Adult Salmon in Northern California

Dr. Herbold, with EPA Region 9, described studies of water quality based on the migration of salmon. The Delta Cross Channel is a controlled diversion channel that diverts water from the Sacramento River into the Snodgrass Slough, near the San Francisco Bay area in California. The opening of the Delta Cross Channel protects water quality at export pumps from salinity intrusion.

In Fall 2001, scientists from EPA Region 9, the United States Fish and Wildlife Service, the USGS, and the California Department of Fish and Game, along with other collaborators, released large groups of adult Chinook salmon with individual tracking devices into the Delta Cross Channel. Scientists conducted this release with the understanding of the status of the channel gates (open/close) and the impact on migration—when the channel gates are closed, salmon smolts remain on track to the ocean, however, when the channel gates are closed, up-migrating salmon adults stray. Therefore, the scientists worked with the channel gates both open and closed, and on both ebb and flow tides.

The study worked to answer the following questions:

- How does the cross channel affect interior delta water quality?

- How does the cross channel affect adult migration through the delta?

- How does the cross channel affect smolt passage?

A series of experiments were conducted to answer these questions. The first study examined the migratory pathways of salmon along the Sacramento River and the San Joaquin River. Salmon were released at the Montezuma Slough along the Sacramento River and at Jersey Point along the San Joaquin River. Study results showed that 84 percent of the salmon were tagged and therefore traveled along the Sacramento River, while 16 percent were tagged in the San Joaquin River.

Another study, the Delta Cross Channel Fish Passage Study, used hydrodynamic instruments to detect the pathway and numbers of fish moving down the Sacramento River and into the Delta Cross Channel. Researchers released 120,000 adult Chinook salmon in the Sacramento River, approximately three miles upstream from the Delta Cross Channel. After the gates of the channel opened, scientists collected 1,282 of the released fish, and approximately 91 percent were captured in the Sacramento River downstream from the channel. The majority (approximately 99 percent) of the salmon were captured at night when the tides were high. Therefore, the researchers concluded that nearly all water quality benefits were obtained when the channel gates were open and that the fish followed the tides of the Sacramento River. The location of the captured salmon reflected past hydrodynamic study results.

Another team led by Dave Vogel, with Natural Resource Scientists, Inc., also studied juvenile salmon in the Delta Cross Channel and those experiments resulted in the same conclusions. In addition, the use of radio equipment to study the salmon, which were injected with antennas, led to more confident, multi-dimensional data because depth locations of the fish were also identified.

Integrated Environmental Planning Across Two States, 15 Counties, and 36 Municipalities: Do You Believe in Miracles

Dr. Linda Rimer, with EPA Region 4, discussed new threats to the environment and human health resulting from urban sprawl. The mission and goals of EPA Region 4 including conducting research, monitoring, and modeling; establishing policies and setting standards; developing rules; writing permits; and conducting inspections. Science has taught the regulators and decisionmakers that the approaches used for growth and urban development have adversely affected the environment because most decisions are made at the local level. Direct and indirect effects of decisionmaking on land use patterns at the local level leads to a reduction in water quality, water quantities, and air quality. Recent research documents threats to human health, as well as the natural environment, as a result of poor, localized decisionmaking.

Generally, the quality of human health is a focus of many politicians; however, the quality of the environment often is not. EPA Region 4 has initiated some early steps to highlight the importance of the environment for decisionmakers. For example, EPA Region 4 established a smart growth network, the Sustainable Urban Environment (SUE) Program, and State Implementation Plan (SIP) credits for land use planning and energy conservation.

Many of these integrated, regional-based programs were piloted in the Centralina regional area (i.e., central North Carolina). Mecklenberg County, North Carolina, is a non-attainment area for the 1-hour ozone standard, and the rivers and waterways of the City of Charlotte discharge into the South Carolina region. Region 4 helps to support a Charlotte/Rock Hill Project that utilizes a "toolbox" to educate leaders and decisionmakers on air, water, and land use (or smart growth) initiatives and approaches. Region 4 also supports the SEQL Program.

With these programs, EPA Region 4 works towards its goals of creating a model to be replicated across the United States to influence politicians and decisionmakers to consider the quality of the environment as a critical priority when initiating land use changes. The science to support these goals can be established by documenting the impact of the built environment on the natural environment, documenting the impact of the built environment on human health, modeling the impacts of the interventions, and providing the model-based decision support tools to local and state governments.

Michigan Environmental Science Board and Protecting Children's Health

Dr. Keith Harrison, Director of the Michigan Department of Environmental Quality (MDEQ) Office of Special Projects, provided an overview of the MESB and the goals of partnering for state and local governments in order to protect children's health. The sole MESB mission is to provide the Governor of Michigan with advice and recommendations on environmental issues based on sound science. The MESB is comprised of a variety of scientists and researchers who are called upon at the request of the Governor. To date, the MESB has submitted 17 reports on specific issues, such as human health and environmental impacts of mercury, chlorine, and lead contaminants; the human health impact of low-level hydrogen sulfide exposure; and cancer trends among firefighters. The MESB also has proposed a uniform fish advisory for use with the Great Lakes; a list of environmental indicators to be used to assess the overall state of the natural environment in Michigan; and Michigan-specific generic cleanup criteria for indoor air inhalation at sites of environmental contamination, low-level radioactive waste isolation facility siting criteria, and environmental standards as they relate to children's health.

An example is the February 2000 document on the Children's Environmental Standards Investigation. This document addressed the MESB's challenges from the Governor: (1) to identify and prioritize the environmental standards that may need re-evaluation as a result of either outdated and/or limited scientific data; and (2) to indicate, where possible, the nature of the type of research to be undertaken to address any identified deficiencies. The children's health document is available at www.michigan.gov/mesb.

The MESB found that risk assessment methodology currently used by the MDEQ to evaluate the level of risk from exposure to specific environmental contaminants closely corresponds to that currently used by EPA. The methodologies of both agencies explicitly consider children when data are available for the specific contaminant under consideration. However, neither methodology incorporate a standardized process to account for possible increased risks in children. Instead, the two agencies rely on scientific judgment based on available information and literature. A large body of data exists in relation to adult exposures to contaminants, but there is little data that distinguish infants and children from adults. Considering these results, the

MESB determined that there is not a compelling scientific rationale for an additional, distinct safety factor to account for exposures of infants and children.

The MESB also determined that the public health goals of specific MDEQ standards are difficult to maintain because they are beyond regulatory authority (e.g., indoor air pollution), either because they are currently unregulated or because similar exposures are allowed under other State or Federal regulations. The MESB recommended that MDEQ and EPA re-evaluate current risk analysis methodologies for addressing and communicating risk to the public. Finally, a process was recommended to keep abreast of pertinent scientific literature and research relating to children, as well as cancer risk assessment, uncertainty factors in non-cancer risk assessment, contaminant mixtures, cumulative risk, indoor and outdoor air contamination, and soil exposures.

Panel Discussion/Questions and Answers

The speakers had an opportunity to participate in a brief panel discussion drawing on questions from the audience.

A brief panel discussion addressed a range of topics. These included: (1) approaches to get local governments to act regionally, (2) ways to educate politicians and elected officials on the importance of the environment and programs or tools available to them, (3) conflicts of interest or differences of opinion within the MESB, and (4) other groups throughout the United States that are similar to the MESB.

Advancing Science Through Environmental Monitoring and Assessment Program (EMAP) Partnerships

Following opening remarks by Dr. Michael McDonald, Director of EMAP, eight speakers provided highlights of EMAP and its applications as well as current and future initiatives involving this web-based tool. The Environmental Monitoring and Assessment Program (EMAP) is an ongoing EPA project that supplies scientists and researchers with tools to better estimate regional, environmental indicators in order to assess environmental conditions. Panel discussions, including an audience question and answer period, followed the early and late afternoon sessions.

Dr. Michael McDonald, Director of EMAP, provided opening remarks and an overview of EMAP, its features, and capabilities as a web-based tool. Dr. McDonald then introduced the other speakers in this two-part session.

EMAP-West: Introduction

Dr. Blair, with the National Health and Environmental Effects Research Laboratory (NHEERL), provided an overview of EMAP and the EMAP-West initiatives. EMAP aims to estimate the current status and trends of selected environmental indicators on a regional basis, estimate geographic coverage and extent, seek associations between indicators and stressors, and provide the tools to prepare annual statistical summaries and periodic assessments. Additionally, EMAP-West hopes to establish a framework for designated uses, develop indicator estimates that can be used in data sets critical to defining quantitative biocriteria, and provide data for models to

support the 303d listing/delisting process. EMAP-West also offers surface water tools to support sample survey design, estimates of ecological indicators, and establishing reference conditions.

When establishing indicators, researchers must individually evaluate indicator criteria by addressing the following questions:

- How can we realistically get this sampling done?
- How can we best measure it (how far upstream or downstream)?
- How responsive is it (e.g., is it going to react to the stressors)?
- How variable is it?
- Can we score it?

Scientists must also consider data management while collecting data for indicators and/or stressors. Researchers should consider the importance of having full and open sharing of data, continuously updated systems that support environmental assessments, and consistent data bases ready to accept data from coastal, surface water, and landscape components across the country (i.e., using the STORET archival system).

EMAP and EMAP-West house the tools to address indicators and stressors, data management, and many other issues. EMAP-West partnerships between EPA, the states, and the Native American tribes strive to create unbiased estimates of the condition of ecological resources, such as streams and rivers, to establish comparative rankings of stressors, to produce tools for biocriteria, and to support a framework for the 303d process.

The EMAP Western Pilot in Region 8

Mr. Karl Hermann, with the EPA Region 8 Ecosystem Protection Program, discussed the EMAP Western Pilot and associated activities involving surface waters, landscapes, stakeholder engagement, and ecological assessment of condition. The objectives of the EMAP Western Pilot project include producing a regional assessment of the ecological conditions of streams in EPA Region 8; developing partnerships with EPA ORD, states, tribes, and the USGS; and improving technology transfer to the states and tribes.

In 2004, members of the EMAP Western Pilot project will work with the USGS to collect data from the Yellowstone National Park basin. Other future EMAP assessment efforts will include studies in the Southern Rocky Mountains (in Montana), other areas of Yellowstone National Park, and other rivers.

Perspective from the State of California

Dr. James Harrington, with the California Department of Fish and Game, discussed the long history of collaboration with EPA involving studies of biocriteria. The current goal of the California Department of Fish and Game is to make a conscious effort to include both biology and toxicology in the State's water programs and in methods of water quality monitoring. California has several water quality boards; however, there is littler interaction between them.

The California Department of Fish and Game is developing biocriteria for California. Efforts include building an aquatic bioassessment laboratory and establishing the California Aquatic Bioassessment Workgroup (CABW). The Department also hopes to develop and promote standardized field and laboratory protocols, and to promote the development of an Index of Biological Integrity (IBI). In order to achieve these goals, the Department works with the Chico State Taxonomy Laboratory, Chico State Research Foundation, and the Rancho Cordova Laboratory. These laboratories work together to conduct research and taxonomy, EMAP and field studies, enforcement, and taxonomy.

The CABW was established in 1994 to create a forum to communicate and exchange aquatic bioassessment information. Since its inception, the CABW has finalized the California Stream Bioassessment Procedures manual, formulated the process for developing biocriteria in California, and provided a forum for updating attendees on bioassessment.

To support the efforts of developing and promoting a standardized and consistent field and laboratory protocols, the California Department of Fish and Game used the California Aquatic Macroinvertebrate Laboratory Network, developed an inter-laboratory QA/QC program, and modeled the CalEDAS Database development.

In the future, the California Department of Fish and Game hopes to develop a new cooperative agreement with EPA to work with EMAP-West data, start a new California Regional Ecological Assessment Program, complete regional reference condition and IBI development, and work on tiered aquatic life uses standards and use attainability analysis guidelines.

EMAP Tribal Perspectives

A Scientist with the Nez Perce Tribe, Mr. Jefferson Davis, described the goals of the Nez Perce Tribe and the role of EMAP in their local science objectives. The Nez Perce are one of the first tribes to adopt an EMAP approach with their own funds.

The Nez Perce Tribe is located in north central Idaho. The reservation involves approximately 750,000 acres across four counties. Approximately 30 percent of the reservation is tribally owned. The remainder of the reservation has been sold to industrial companies or other businesses. The tribal reservation has diverse landscapes, and therefore, requires diverse approaches when managing their environment. Most of the reservation's land is used for cultural activities, agriculture, recreation, timber management, and livestock management.

The Nez Perce developed an interest in the EMAP project when Mr. Davis attended an EMAP training session in June 2001. Mr. Davis encouraged the tribe to fund its own EMAP, and in 2002, Mr. Davis and other scientists started a training review of EMAP field sampling protocols. In 2003, the tribe initiated its own sampling for EMAP data, and will complete a final report of its findings and results in 2005.

The Nez Perce Tribe will use the EMAP bioassessment applications to develop water quality standards and criteria, complete a 303d list of impaired areas based on the state of their aquatic community, and create total maximum daily loadings, among other project goals. EMAP will play a major role in assessing the current condition of streams within the reservation.

National Coastal Assessment: Past, Present, and Future

Dr. Kevin Summers, with NHEERL, discussed the National Coastal Assessment Program and the use of EMAP to achieve goals to build the scientific basis as well as the local, state, and tribal capacity to monitor the status and trends in the condition of the Nation's coastal ecosystems. The National Coastal Assessment Program also hopes to integrate states and tribes in utilizing status and trend data to obtain a national perspective.

There remain some uncertainties and questions regarding EMAP. For example, researchers are still unclear of the status, extent, and geographic distribution of ecological resources. Other questions include: (1) what proportions of these resources are declining or improving, where, and at what rate; (2) what factors are likely to be contributing to declining conditions; and (3) whether pollution control, reduction, mitigation, and prevention programs are achieving overall improvement in ecological condition.

Through the National Coastal Assessment Program, scientists will complete a probability survey, estimate the ecological extent and conditions of resources, and characterize trends and the conditions of resources to represent spatial patterns with known certainty. Another activity includes training states and tribes to use the methodology in sampling and training on sampling devices. This will require a QA document. States that will benefit from this survey include Maine, New Hampshire, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, North and South Carolina, the southeastern corridor, Texas, California, Oregon, Washington, Alaska, Hawaii, and Puerto Rico.

According to some survey results, indicators such as water clarity, dissolved oxygen, sediment contamination, and fish tissue show that overall conditions around the country are very poor. Also, no data were collected in the Great Lakes; therefore, estimates of indicator values were used. Future reports will include more data, but will not yet data from the Great Lakes. As researchers of the assessment program draw conclusions on overall environmental conditions, the step of integrating the monitoring framework still needs to be addressed.

EPA is currently helping states to develop sampling strategies to determine the overall condition of aquatic resources. Research from the National Coastal Assessment Program will help states to determine where sampling is needed in order to confirm impairment. Another recommendation of the National Research Council on the CWA Section 303b listing process was the use of preliminary lists of impaired waters, and the work of this Program should provide a rationale to develop this preliminary listing. Future activities of the National Coastal Assessment Program include supporting water quality goals, completing condition research to develop probability of impairment models based on landscape characteristics and their relation to water quality, using these impairment models to assist the states in completing integrated 305b and 303d reports, and determining the cause of impairment in order to develop total maximum daily loads for impaired waterbodies.

The Interactions of EMAP and the Southern California Coastal Water Research Program: Help in the Past, Necessity for the Future

Dr. Stephen Weisberg, with the SCCWRP, discussed EMAP's evolving influence on Southern California's coastal monitoring programs. The California coast is the most monitored coast in the country, and agencies complete routine monitoring of its rivers, lakes, and other waterways, excluding estuaries. EMAP has influenced California's monitoring protocols over the last 10 years.

Currently, California has nine water monitoring boards, and they each follow different protocols and have different assessments. To address this, the SCCWRP developed three cooperative regional monitoring surveys involving studies with 12 organizations completed in 1994, with 62 organizations completed in 1998, and with 68 organizations completed in 2003. This research effort stemmed from the need to look at all coastal discharges using the same approach. EMAP has had a big influence on this program.

The SCCWRP program seeks to answer the following questions with the help of EMAP:

- What is the spatial extent of chemical contamination and the associated biological effects?
- What probability-based sampling design could be used to evaluate potential impact areas?
- What multiple indicators should be evaluated at each site?

Answering these questions with EMAP will help this SCCWRP to identify sediment totals, hot spots, priority sites in the State, and concentration levels in priority sites, as well as other sites in California.

In order to determine sediment concentrations in waterways, SCCWRP researchers study fish contamination. Researchers also have expanded the study areas to include beaches and wetlands. With the use of EMAP, the SCCWRP can bridge the gap between indicator research and implementation in state monitoring programs.

The Role of the National Coastal Assessment in Developing a Continuing South Carolina Estuarine Monitoring Program

Dr. Robert Van Dolah, with the South Carolina DNR, described the role of the national coastal assessment in developing a continuation of South Carolina's estuarine monitoring program. The South Carolina estuarine monitoring program is supported by two State agencies (DNR and Department of Health and Environmental Control). The Department of Health and Environmental Control conducts ambient surface water monitoring by routine sampling of the state's freshwater and estuary sites, and monitors for water quality and sediment quality. The DNR monitors fishery resources through numerous inshore and offshore monitoring programs on state-wide and regional scales. The South Carolina environmental monitoring programs indicate that pollution and habitat alterations are driving the poor conditions. However, new monitoring programs are needed in order to integrate water and sediment monitoring with biological response measures, increase spatial coverage, and expand monitoring to other critical habitats.

South Carolina is working towards these goals with the help of the South Carolina Estuarine and Coastal Assessment Program (SCECAP). SCECAP objectives are to monitor the conditions of biological habitats and report those findings to the public. Biological habitats monitored include tidal creek habitats and open water habitats, such as rivers, bays, and sounds. Tidal creeks are primary nursery habitats and are very important because they serve as the first point of input into estuaries. In addition, water sediments and pollutants found within the tidal creeks will influence the water quality of estuaries.

The monitoring approach used for the biological habitat studies consist of a probability-based sampling design that ensures an unbiased sampling protocol and sampling of 60 stations each year. Habitats are monitored for salinity, dissolved oxygen, pH, temperature, total nutrients, dissolved nutrients, biological oxygen demand, fecal *coliform* bacteria, metals, sediment contaminants and toxicity, phytoplankton composition, and finfish and crustacean community measures. According to the 1999-2000 studies of estuarine habitat, integrated water quality scores showed that 38 percent of the State's creeks had poor conditions, and 11 percent of the open water habitat was in poor condition. Integrated sediment quality scores showed that 38 percent of the State's creeks had poor conditions, and 30 percent of the open water habit was in poor condition. When merging water quality, sediment quality, and biological quality, 12 percent of the State's creeks had poor conditions, 8 percent of the open water habitat was in poor condition.

SCECAP is providing good data on the conditions of the South Carolina coastal habitat. Data improvements in recent studies include the addition of nursery habitat and estimates of proportion of the State's water that meets or fails expected conditions. Also, the data have been very useful to South Carolina by showing the need to continue with research efforts.

The Application of EMAP and REMAP in the EPA Regions

EPA Region 2 Monitoring Coordinator, Ms. Darvene Adams, described EMAP and Regional EMAP (REMAP) activities. EPA Region 2 provides technical assistance, funding for special programs such as REMAP, and training. The goals of the Regional Office are to support state monitoring programs and address regional priorities. The state monitoring programs strive to comply with the CWA, and therefore, study spatial coverage, indicators, and water quality standards.

Previously, state compliance with the CWA within EPA Region 2 was target-based and focused on only one chemical or pathogen. Also, some water resources were not addressed because funding was not available. After 30 years since the inception of the CWA, states within EPA Region 2 have not fulfilled their compliance obligations for any water resource. In order to address these issues, EPA Region II has enlisted support from EMAP and hopes to achieve state goals with the use of EMAP tools, including the EMAP design based on probability, approaches for indicator development, and approaches for water quality standards.

Also, EPA Region 2 developed REMAP in order to provide status or trends, address broad scale or high interest issues, make associations, demonstrate the probability approach, and provide management support at different scales. To date, REMAP has provided baseline data for the New York/New Jersey harbor areas (including data on toxicity, chemistry, and benthos), and has

been used to study watersheds of high interest (or impaired watersheds). REMAP also incorporates groundwater in the assessment data for state watersheds. Future REMAP goals include:

- Additional studies on wetlands, groundwater, arid lands, large rivers, offshore, and Alaskan ecosystems
- Complete transfer of capability to the states and tribes
- Reference conditions
- Integrated monitoring for status/trends and impaired water identification.

Panel Discussion/Questions and Answers

The speakers had an opportunity to participate in a brief panel discussion drawing on questions from the audience.

A brief panel discussion after the early afternoon and late afternoon sessions addressed a range of topics. Topics from the early afternoon discussions included: (1) the importance of groundwater being factored into the EMAP-West data; (2) use of wetland density as a critical stressor; (3) and the Nez Perce tribe's future goals and use of EMAP data. Topics from the late afternoon discussions included: (1) the goals of the National Coastal Assessment program beyond 2006; (2) pathogens in California; (3) the use of groundwater to determine sediment contamination; (4) existing work with California officials on the Southern California Coastal Water Research Program; (5) studies involving invasive and exotic species; and (6) the cost of monitoring programs.

Working with Tribes: Cultural Values and Tribal Lifeways Inform Health Assessments

Following opening remarks by Mr. Thomas Baugh, with EPA Region 4, five speakers addressed examples of partnering between tribes and government agencies to maintain healthy environments within the reservations, to gather new or better data, to develop models or modeled approaches, and to communicate environmental risks and conditions to members within the reservations.

Mr. Thomas Baugh, with EPA Region 4, discussed the overview and goals of this session. Then, Mr. Baugh introduced the session speakers.

Tribal Partnerships in Pesticide Management to Protect Human Health

Ms. Sarah Ryan, with the Big Valley Rancheria, explained the traditions of the Big Valley Rancheria reservation and their goals for environmental improvement. The environmental goals of the Big Valley Rancheria are to gather as much information as possible on health hazards and to provide outreach to the community. In order to meet traditional and environmental goals, the

Big Valley Rancheria uses income from its tribal-owned casino and also relies on grants from the United States. Department of Housing and Urban Development, EPA, and the Bureau of Indian Affairs.

Pesticide management and community recycling are priority goals. Hunting and gathering from the lands of Big Valley Rancheria is a long standing tradition of the community. Big Valley is a descendent of the Xa-ben-na-po Band of Indians, and Xa-ben-na-po is defined as hunters and gatherers. The tribal members occupy 375 acres and are committed to protecting their lands. However, pesticide use in Lake County has resulted in diverse environmental and human health effects within their community.

Pesticides are used to protect pear, walnut, and apple trees as well as wine grapes. There are residents that live as close as 60 to 100 feet from pear and wine grape orchards, respectively. Tribal schools are less than 40 feet from pear orchards, and residents along the Soda Bay Road are less than 50 feet from pear orchards. Tribal elders also have documented pesticide use outside of their homes. These repeated exposures have resulted in asthma in five family members.

In 2001, the Big Valley Rancheria completed a pesticide history investigation and report, which focused on the pesticides 2,4-D, paraquat, azinphos-methyl, chlorpyrifos, methyl bromide, and petroleum oils. The Big Valley Rancheria also has investigated 2002 data on exposure from pesticide spray drift, including chlorpyrifos (lorsban).

It is vital that Big Valley Rancheria address pesticides use and pesticide drift in the areas lying between Lake County and the reservation. Tribal members use plants for food and medicine, use baskets built with plants, use plant products for cooking utensils and ingredients, and even use plants for baby rattles. These plant uses result in exposure to pesticides. Other tribal environmental issues include native plants, repatriation of items, fish warnings, mercury, and pesticides found in Clear Lake.

Establishing Self-Sufficiency in Alaska Native Communities to Minimize Exposure to Environmental Contaminants

Ms. June Gologergen-Martin, with the Alaska Community Action on Toxics (ACAT), explained the goals of the St. Lawrence Tribe and support received from the ACAT Program. There are 229 tribes in Alaska, and St. Lawrence is a tribal-owned island. St. Lawrence Island has worked to address issues of limited funding, information gathering on the nature and extent of data on island contaminants, the exclusion of their local input into decisionmaking efforts regarding surrounding areas, and contaminants resulting from United States military sites. St. Lawrence Island also recognizes trends in local and traditional knowledge and wisdom not being adequately integrated into younger generations. In order to address some of these challenges, members of the St. Lawrence Island community work with the ACAT Program. The initial ACAT support resulted from a meeting with Annie Alowa, formerly with ACAT, and the receipt of a grant to help the St. Lawrence community address the health issues prevalent on the island.

With ACAT assistance, St. Lawrence partners with the communities of Gambell and Savoonga, Norton Sound Health Corporation, and the State University of New York to achieve several environmental goals, including:

- Acquisition of more information about environmental health clinics
- Education and involvement of young people
- Development of tribal abilities to interpret data
- Arrangements for advance planning and creation of information management protocols
- Development of strategies to increase funding allocated to the DOD for cleanup statewide and nationally
- Development of strategic partnerships for policy advocacy needs
- An increase in elder input.

On a project basis, St. Lawrence is working with other organizations to identify sources of contamination affecting the communities of St. Lawrence Island, including military sites and distant sources; to determine health problems that may be linked to environmental contamination; and to develop cleanup protocols for contaminated sites. The tribe also hopes to create a training program about prevention and treatment of environmental health problems, and to develop a model of communication that might be helpful for other Alaska Native communities in addressing environmental contamination.

To date, the tribe has established an advisory committee with representation from the tribal government, city council, and village corporation of the Savoonga and Gambell communities; held leadership and community meetings in Gambell and Savoonga; completed portions of a pilot study to determine environmental exposures to contaminants, as well as other environmental studies; and held planning meetings with community leaders.

Bioaccumulative Toxics in Native American Shellfish

Mr. Larry Campbell and Ms. Jamie Donatuto, with the Swinomish Indian Tribal Community, discussed their current project of studying bioaccumulative toxics in subsistence-harvested shellfish on the Swinomish reservation. This project is supported by an EPA grant.

The Swinomish reservation is located 75 miles north of Seattle, Washington, and has 750 tribal members currently living on a reservation covering approximately 7,400 acres of which 2,900 acres are tribal-owned. Their reservation is unique in that 90 percent of their land is surrounded by water. Therefore, shellfish are vital to their community and are a key subsistence food of the Swinomish tribe. Shellfish are incorporated into the common diet and sold to produce funding for the tribal families. The community has environmental and human health concerns because heavy metals, PCBs, lead, mercury, dioxins, and furans are common contaminants found in the nearby waters and in the shellfish.

To address these concerns, the Swinomish tribe uses their grant funding toward the following goals:

- Determine whether Swinomish people who eat shellfish harvested from the reservation or other nearby areas are exposed to bioaccumulative toxics by testing sediment, clams, and crabs

- Effectively communicate those risks in a culturally appropriate manner

- Develop mitigation measures

- Confirm major health problems on the reservation that may be related to eating contaminated shellfish

- Develop hypotheses between the health problems and toxics found.

Testing of the shellfish, as well as land, involves the collection of sediment, clam, and crab (shellfish) samples, as well as developing additional protocols to prevent further contamination. The reservation scientist will collect data to determine concentrations and other information on heavy metals, such as arsenic, copper, cadmium, selenium, mercury, lead, and nickel; PCBs; polycyclic aromatic hydrocarbons (PAHs); dioxins and furans; chlorinated pesticides; and butyltins. Sampling locations were chosen based on historic and present frequencies of subsistence food gathering.

The reservation also is completing their *Tox in a Box* ambassador's guide to educate school age children on toxics in the community and common health effects determined from their studies. Tribal members also participate in community gatherings where reservation scientists disseminate environmental and human health information. Finally, the tribe provides public service announcements on the Swinomish cable channel to communicate findings and risks.

Activities also include the development of mitigation methods since stopping the harvest of shellfish is not an option and moving shellfish harvesting to another area is also not an option given the treaty agreements required for such an action. Alternatives must be found to cleanup the shellfish contamination and to prevent further exposure and contamination.

The Swinomish tribe is also working closely with EPA to build capacity, yet to move forward they have begun to hire scientists to capture more scientific information as well as to gain credibility with government and state scientists. The focus is on an agenda of empowerment to understand the issues, move forward, and take action to fix problems as well as to provide their own funding to support these initiatives independent of Federal monies.

Moving Science into Action – Step One: Get the Data!

Following opening remarks by Ms. Pamela Russell and Mr. Mike Flynn, with the EPA Office of Environmental Information, five speakers addressed the acquisition and analysis of data critical

to completing environmental and human health risk assessments as well as current initiatives and partnerships.

Uses of Toxics Release Inventory Data

Ms. Gail Froiman, with the Office of Environmental Information, introduced the EPA Toxics Release Inventory (TRI) program and discussed general uses of the data collected under this program. EPA initiated the TRI program when a chemical spill at Union Carbide in Bhopal, India, resulted in irrecoverable environmental damage. The TRI program, which falls under the Emergency Planning and Community Right-to-Know Act, requires the reporting of toxic chemicals from industrial facilities in the United States. Companies must report the uses of toxic chemicals, the approximate amounts maintained onsite, the management and media releases of toxic chemicals, reductions, and pollution prevention activities used on a facility-by-facility basis. All data are made public, and this requirement has recently resulted in some controversy.

Companies reporting toxic chemical data must meet predetermined criteria in order to report their toxic chemical data to TRI. The reporting of toxic chemical data is required if the facility employs 10 or more full-time equivalent personnel; is listed under specific groups of Standard Industrial Classification codes; and manufacture, produce, or otherwise use toxic chemicals meeting or exceeding specific thresholds established by EPA. In 2001, EPA added its persistent, bioaccumulative, and toxic (PBT) chemical rule to the TRI regulations. Under the additional rule, facilities must report on PBT chemicals that meet or exceed reduced reporting thresholds.

The data collected from TRI reporting can help states to set priorities. These data may also be used by community organizations. Examples of such use include the following:

- A community organization in Louisiana used TRI data to refute the claims of a commodity chemicals company seeking to locate its facility in Louisiana (see http://www.leanweb.org)

- The Oneida Tribe of Wisconsin used TRI data to inform a local labor union about health risks at their workplace, and the union in turn lobbied their employer to reduce the emissions at contract renewal (see http://www.oneidanation.org)

- The Ecology Center, working with residents of Flat Rock, Michigan, discovered from TRI reports that emissions from an automobile assembly plant had increased over time, and the environmental organization and residents together negotiated an agreement with Auto Alliance International to lower the emissions (see http://www.ecocenter.org)

- Communities for a Better Environment combined 1996 TRI data with GIS mapping data to develop environmental justice conclusions for Los Angeles County, California (see http://cbecal.org).

TRI data are often used by industry, financial services, government, and international affiliations for diverse purposes. For example, the Haartz Corporation uses their TRI estimates to determine cost savings of $200,000 per year resulting from improved control of methyl ethyl ketone emissions. In another example, Governor O'Banno influenced Indiana companies to voluntarily

agree to reduce TRI emissions by 50 percent. In addition, Green Century Funds uses TRI data as a measure of corporate environmental performance.

More information on TRI can be accessed at the TRI Explorer website at www.epa.gov/triexplorer/. TRI data also can be accessed via the EPA ENVIROFACTS database.

Integration of State and County Stream Monitoring Programs: A Maryland Case Study

Dr. Ron Klauda, with the Maryland DNR, and Mr. Keith Van Ness, with the Montgomery, County DEP, described a partnership with EPA involving the use of TRI data to improve stream monitoring and watershed assessments. The Maryland DNR began its stream monitoring program in 1993, and in 1995 expanded the program to include state-wide streams and waterways. Montgomery County initiated its stream monitoring program in 1994.

With EPA funding, the Maryland DNR is conducting a Biological Stream Survey to monitor over 1,000 stream sites over several years; approximately 200 to 300 sites are being monitored each year. The goal of the Biological Stream Survey is to address key issues for program integration and to develop approaches that can be applied elsewhere. The survey results will be analyzed by a probability-based design, and the samples are randomly selected. The Maryland DNR is focusing on water chemistry, physical habitats, and biological communities. The Maryland DNR surveys also will help to determine reference-based indicators of integrity for fish, benthic invertebrates, and physical habitats; hotspots of biological diversity; and 305(b) reporting and 303(d) listing.

The Montgomery County Stream Monitoring Program involves the study of over 400 sites county-wide, with approximately 90 sites monitored each year. This monitoring program will help the Montgomery County DEP to characterize stream conditions, develop a county-wide Stream Protection Strategy, target and assess watershed restoration effectiveness, meet watershed National Pollutant Discharge Elimination System (NPDES) monitoring requirements, assess impacts of development, and determine 305(b) reporting and 303(d) listing.

As a result of integrating the monitoring projects of these two Maryland agencies, researchers can obtain an increased confidence in estimates of stream condition, maintain consistency in public statements about stream conditions, reduce the costs of sampling programs, and increase the use of local information in state estimates of stream conditions.

The integrated monitoring study supports the contention that the Montgomery County and State stream monitoring efforts can be effectively integrated. Researchers also suggest that EPA consider similar integration of other programs through comparability analyses across states in the Mid-Atlantic and other regions.

Effects of Urban Growth on Fish Assemblages in a North Carolina Metropolitan Area, 1970-2000

Dr. Jonathan Kennen, with the USGS, discussed ongoing projects related to urban growth in partnership with the EPA Office of Environmental Information. Urbanization is an increase in

human habitation, combined with increased per capita consumption and extensive landscape modification. An approach to address adverse effects of urbanization is to use aquatic communities to evaluate the influence of changes in the environment. Aquatic communities are susceptible to multiple physical, chemical, and biological influences (or stressors). Researchers can use these stressors to determine changes and trends in the environment.

The USGS and EPA have teamed together to: (1) evaluate the relationships among land use, extant fish species composition, and stream water quality, and (2) determine if there are significant relationships between fish assemblage structure and environmental quality across a disturbance gradient. Study locations include Phoenix, Arizona; Detroit, Michigan; Minneapolis and St. Paul, Minnesota; and Chicago, Illinois; Milwaukee, Wisconsin; and the Raleigh-Durham area, North Carolina.

The Raleigh-Durham area represents a contiguous metropolitan area surrounded by Cape Fear and two other lakes. A 20-mile buffer of major drainage basins also surround the area and was chosen to be included in the study area to aid in projecting urban growth of the metropolitan area beyond 2000.

The fish community studies involve the use of the double pass assessment method in upstream and downstream directions. Land use data from the National Land Cover Database, North American Land Cover, aerial photos, and other GIS data layers also are used in the study of the fish communities. Population, transportation, and economic data are gathered from the United States Census, the Texas Transportation Institute, and state and local governments to help determine the effects of land use and urban sprawl on fish communities, and therefore, the environment.

The preliminary results from the Raleigh-Durham area study indicate that urban influences, such as urban land cover, population density, and other related variables, impose the strongest negative influence on the fish communities. Also, increasing forest fragmentation and patch diversity, as well as a decrease in contiguous forest corridors, adversely affect the fish communities in the Raleigh-Durham area. For example, the loss of a protective stream buffer can destabilize stream banks and eventually leave streams more vulnerable to erosion and stream bank damage. Finally, the preliminary study results also showed that edge forest, percent forest cover, and the portion of large forest patches in a basin are important for maintaining healthy streams.

Dynamic Choropleth Maps

Dr. William Smith, with the Office of Environmental Information, described the uses of TRI data in creating dynamic choropleth maps to visually depict trends in human health and environmental conditions. TRI Explorer, accessed from the EPA website, and a JAVA-based web tool are used to create the dynamic choropleth maps. The map tool can be manipulated using all web browsers. The dynamic choropleth maps are created using several data sets of environmental, human health, statistical, and geographic information, and the data tree in the tool accesses 10 data cubes and 300 indicators that determine trends in the environment, human health, demographics, and economics.

Dynamic choropleth maps have user controls and sliders that allow real-time interaction with the database and selection of the specific indicators to consider in determining environmental conditions and human health trends in county locations across the United States. On each map, each county is color coded for the values of the principal data component with a separate designation for a county with missing data, or with data that have been filtered out.

Dr. Smith demonstrated the various levels of data sets, a maximum of three, that a user can choose to display trends in human health risks or diseases among ethnic groups, geographical areas, and age groups. The latest development of the dynamic choropleth map web tool can be accessed at http://users.erols.com/turboperl/dcmaps.html or www.epa.gov/triexplorer.

Emerging Innovations in Regional Ecosystem Protection

Five speakers provided examples of regional projects to determine the environmental conditions of ecosystems and goals in order to protect these ecosystems from further exposure to hazards and toxics. A panel discussion including an audience question and answer period followed the presentations.

Regional Ecosystem Protection: A Pattern, An Opportunity, A Challenge?

Mr. Doug Norton, with the Office of Water, provided highlights of an EPA workshop on critical ecosystem assessment and the priorities determined from the workshop. EPA Regions 3, 4, 5, and 7 have partnered to develop ecosystem modeling and other tools, and have become a network in geospatial modeling. The current partnerships allow the EPA Regions to be EPA's best unit for implementing cross-program ecosystem protection.

Geospatial modeling can help researchers analyze ecosystem health. Geospatial modeling involves the use of GIS to show the contributions of different ecosystems. Ecosystem protection assessment is a priority in Region 7. Goals of the geospatial modeling programs and networks are to: (1) apply the concept of regional-scale ecosystem protection, (2) determine appropriate national roles, and (3) protect, sustain, or restore the health of people, communities, and ecosystems using integrated and comprehensive approaches and partnerships. Applying the concept of regional-scale ecosystem protection requires regional dialogues with partners to identify widely valued ecological endpoints, regions and states must identify their ecological identity and heritage, the regions must identify places and processes critical to regional ecological health, and the researchers must maintain mainstream cross-program use of centralized data and tools.

The second goal of geospatial modeling, to determining appropriate national roles, includes the development of core data sets as well as decision or priority setting tools, the provision of core information and tools, support to regional initiatives that align with national program goals, the conduct of research and technology transfer activities, and the generation of an introspective look at national program ecosystem effects.

The goal "to protect, sustain, or restore the health of people, communities, and ecosystems using integrated and comprehensive approaches and partnerships" is taken directly from the EPA Strategic Plan Goal 4, Healthy Communities and Ecosystems. This includes efforts to maintain

regional and state ecological identities, create more partnerships and program integration, placing the geospatial data and tools in the mainstream, and protection of critical ecosystems.

Use of Geospatial Tools to Identify High Quality Midwest Ecosystems (Landscape Scale Characterization of Ecosystem Health in the Upper Midwest)

Dr. Mary White, with EPA Region 5, discussed the use of geospatial tools by EPA Region 5 over the last several years to assess ecosystem condition. High quality ecosystems have three priorities: (1) diversity, (2) sustainability, and (3) rarity in endangered species. These priorities have been used to characterize ecosystems, and the characterizations would serve as indicators.

Using geospatial analysis to characterize ecosystems, researchers developed a diversity composite layer to determine land cover diversity calculated by ecoregion; temperature and precipitation maximums by ecoregion; appropriateness of land cover; and contiguous sizes of undeveloped areas.

The sustainability composite layer consists of a fragmentation layer and a stressor layer. The fragmentation layer includes area and perimeter calculations, waterway impoundments per water body, road density, contiguous sizes of individual land cover types, and appropriateness of land cover. The stress layer includes airport noise and aerosols, Superfund sites, hazardous waste cleanup sites, water quality summaries from the BASINS model, air quality from the OPPT air risk model, waterway obstructions, and urban disturbance.

Finally, a rarity composite layer consists of land cover rarity by ecoregion, species rarity, the number of rare species, and the number of rare species per taxa.

Examples were provided of individual composite maps and maps created by combining the three composites with color coding to represent areas with poor scores, which in turn indicate poor ecosystems. Combining the three composite layers, each representing a key component in a healthy ecosystem, enabled researchers to develop an overall "score" useful in evaluating ecosystem condition. Within EPA Region 5, the average ecosystem score was 143, and individual scores ranged from 10 to 288.

A triage model, where sustainability scores are plotted against diversity results in a scattering effect and in a triage effect, was also described.

Synoptic Model to Rank Wetland Ecosystems for 404 Permitting: An Application of Regional Critical Ecosystems Protection

Ms. Brenda Groskinsky, with EPA Region 7, presented a specific analytical process, synoptic modeling, to rank wetland ecosystems. National surveys indicate that a large proportion of historic wetlands have been replaced by other land covers and use types. Studies show that within EPA Region7, states have experienced pre-settlement wetland area losses: in Idaho, researchers estimated a 95 percent loss; in Missouri, an 87 percent loss; in Kansas, a 48 percent loss; and in Nebraska, a 35 percent loss.

There is a need for prioritization to fairly address problem ecosystems. EPA Region 7 aims to reduce the loss in wetland species biodiversity and will need to focus on existing activities (e.g., CWA Section 404 permit reviews). The goal is to obtain and use a defensible, rigorous, and repeatable framework.

A synoptic framework was chosen for this effort. Variables are the environmental indicators and models produce indices enabling results to be ranked. An indicator is a direct measurement that provides information about other conditions. An index is a numerical quantity, usually dimensionless, denoting the magnitude of some effect and can also be used to denote quantity. The conceptual model focuses on wetland prioritization and the prioritization methodology is analogous to a cost-benefit ratio. The prioritization looks at changes in risk rather than values of risk, and considers marginal increases in impacts to regional wetland species and the risk avoided.

Such a synoptic framework must be quantitative and appropriate in scale. EPA Region 7 hopes to use information that is not too costly and to take advantage of data collection opportunities to gain ecological knowledge and develop theories. The synoptic model will help to ensure that relevant data are included when providing ecosystem protection.

As a result of the ecosystem prioritization effort, EPA Region 7 researchers created a management tool that can assist in making decisions about resource allocation; enable resource managers to place wetland site-specific decisions with regional context; and protect wetlands. The EPA Region 7 researchers also expanded the synoptic processes to include terrestrial and aquatic areas. The resultant rankings are appropriate environmental measures.

Southeastern Ecological Framework's GeoBook – Software for Mapping Partnerships and Ecosystem Protection

Dr. John Richardson, with EPA Region 4, presented highlights of the Southeastern Ecological Framework's GeoBook project. A team of scientists, including Dr. Richardson, is looking at the limited natural resources that remain to determine appropriate ways to study and protect these resources. The methodology involves the use of GIS modeling to identify ecological hubs, determine model parameters, identify linkages, and complete an ecological framework. This holistic systems approach is necessary to avoid fragmentation of studies or exclusion of pertinent data.

The EPA Region 4 researchers modeled the Florida Ecological Network that uses a GIS approach to protecting the environment. In developing the ecological framework, EPA Region 4 must consider the varied types of ecological areas, and therefore, must select an ecosystem consisting of optimized hubs. Biodiversity, ecosystem services, threats to ecological integrity, and recreation potential are prioritization categories in the Southeastern Ecological Framework.

The EPA Science Advisory Board reviewed the proposed Southeastern Ecological Framework, and recognized and praised the significant efforts undertaken to create such a framework, which is useful for integrating EPA programs in regions, as well as for providing a landscape context for decisions by states, local governments, and private landowners in a region. The Science Advisory Board recommended that the Southeastern Ecological Framework be enhanced to

include a wider range of ecological attributes that are important to regional ecological integrity. Also, the Science Advisory Board also recommended that the process for setting criteria to select priority lands be made more explicit and that the criteria and individual data layers used in the Framework receive additional peer review. With these caveats noted, the Science Advisory Board agreed that application of the Southeastern Ecological Framework approach would be beneficial in other regions of the United States, although different data layers and/or different criteria for selecting priority areas likely would be needed.

As a part of this project, EPA Region 4 also is developing a Southeastern Ecological Framework GeoBook. The GeoBook enables researchers to answer the following questions:

- How can our green space protection efforts support clean drinking water for our community?
- What funding sources are available to support water quality protection in our community?
- Which land is at most risk to developmental pressures?

The GeoBook also supports decisionmakers in identifying issues that are important to the surrounding communities, and supports easy access to natural resource data and information. Decisionmakers using the GeoBook also receive support in prioritizing locations, identifying potential funding for water quality protection and improvements, protecting drinking water sources in surrounding communities, and identifying potential threats to the critical ecosystem that services a community.

EPA Region 4 is working towards a national ecological framework that will provide a baseline ecological framework assessment that is consistent across the United States, is temporally repeatable with new National Land Cover Data, and is linked to programmatic needs and activities. The national framework would have to be adaptable to individual regions.

The Mid-Atlantic Highlands Action Program: Transforming the Legacy

Mr. Tom DeMoss, with the Canaan Valley Institute, described the Mid-Atlantic Highlands Action Program, which provides support and training for the end user and the background hardware and software to gather other data tools. The Mid-Atlantic Highlands Action Program is a citizens-inspired program for collaborative monitoring, research, management, and restoration activities within the Mid-Atlantic Highlands. EPA commits two, full-time senior staff to the project; contributes outreach, science, and technical staff to assist with project activities; and provides education, training, and demonstration sites for users.

EPA ORD has focused on the Highlands for the last 10 years. Highland areas are prime examples of biodiversity; they have terrestrial and aquatic diversity and serve as the home to national hotspots or areas of concern. These diverse areas also contribute to the Nation's economy claiming earnings of approximately $26 billion per year from the tourism industry and $11 billion per year from the forestry industry. These areas also contribute to the economics of energy since they are natural resources for coal, oil, natural gas, and wind.

However, landscape indicators show that 47 percent of the Highlands region is rated fair or poor. Based on an assessment of the types of birds found, 57 percent of the landscape is not in good condition. Fish assessments indicate that 67 percent of the stream miles in the region fail to meet

a good rating, and assessment of aquatic insects indicate that 75 percent of the stream miles in the region are in fair or poor condition.

Economic conditions in the Mid-Atlantic region are poor. There are high rates of children in poverty, low educational attainment, high unemployment rates, low labor force participation rates, and low per capita income. These conditions result in environmental justice issues and migration of the working-age population out of the region to obtain better living conditions.

The Mid-Atlantic Highlands Action Program will improve economic conditions and provide opportunities for stewardship. Through this initiative, researchers may be able to revitalize 18,000 stream miles and 5,000 square miles of forest in the Mid-Atlantic region and reduce sediment loadings by approximately 105,954,000 tons per year. The Mid-Atlantic Highlands Action Program also may create 3,000 jobs in the Mid-Atlantic region.

Panel Discussion/Questions and Answers

The speakers had an opportunity to participate in a brief panel discussion drawing on questions from the audience.

A brief panel discussion addressed a range of topics. These included: (1) use of geospatial data in environmental regulations; (2) support from EPA to provide funding and other needs in ecosystem protection, including the use of geospatial modeling; and (3) the role of economics in ecosystem protection to ensure that the economic benefits can be understood by decisionmakers.

Site Characterization and Decision Analysis of Contaminated Sediment

Following opening remarks by Dr. John Bing-Canar, with EPA Region 5, four speakers discussed various scientific and analysis aspects regarding the study of contaminated sediments.

Dr. John Bing-Canar, with EPA Region 5, provided opening remarks and introduced the presentations of this session. All of the presentations addressed diverse scientific and analytical aspects involved in the assessment and remediation of contaminated sediments.

Introduction of Concepts and Tools

Mr. Brian Cooper, with EPA Region 5, provided an overview of an EPA Region 5 Field Environmental Decision Support (FIELDS) System to complete site characterization and decision analysis for a study of contaminated sediment. This is an important goal of EPA Region 5 because the use of models, tools, and methods shorten the time required to complete projects and studies in the Superfund remedial investigation/feasibility study process and provide tangible benefits of integrating the methods characterization.

The University of Tennessee, contractors, and other government agencies such as the National Oceanic and Atmospheric Administration (NOAA) support the development of this system. There was no existing fully integrated system and the team worked with OSCs and remediation managers to know the needs of remediation efforts. This strongly supported the development of

decision analysis and visualization tools for scientifically-based decisionmaking that is reproducible and defendable. FIELDS addresses projects predominantly in Region 5, but supports projects elsewhere in the United States, China, and Latvia to address contaminated soil and sediment.

The FIELDS technology combines GIS, global positioning system (GPS) for accurate spatial coordinates, visualization (two- and three-dimensions), and database access and query capability to support field planning, create data storage, and provide for spatial analysis and modeling for remediation decisionmaking. Benefits of this technology include increased speed of analysis through automation, the ability to visualize contaminant location and movement, and tools for spatial analysis and geostatistics integrated with the database of information. Use of this technology also provides standardization in the analyses to obtain results that are reproducible and defendable.

Typical steps in site characterization at sediment sites involve compilation of historical data, acquisition of new data, and data analysis followed by decision support analyses such as contaminant concentration and movement patterns, multi-dimensional visualization, and remediation scenario development and assessment. The FIELDS system serves as a repository for all of the data for the project. A Sample Design Module assists in designing new data collection efforts, including considerations of the number of samples to be taken, sampling locations, data quality objectives, and funding constraints; the system also includes a variety of sampling approaches including judgmental, random, systematic, and linear as well as the ability to assess the likelihood of missing a "hot spot" based on the sampling approach selected. The sampling design can be exported to a GPS unit for subsequent use in the field to find the pre-selected locations.

The FIELDS system includes a number of query tools to extract data for analysis regardless of storage form. The system also includes a variety of statistical and other data analysis techniques to assess the collected data, including the ability to estimate the total amount that is contaminated and average contaminant concentration distribution across a specified depth as well more advanced techniques such as variography correlation models and Krieged interpolation models. The system also supports the design of secondary sampling efforts such as adaptive fill or radial nested design. Data analysis and interpolation tools for decision support include algorithms to delineate "hot spots" and to estimate contaminant mass/volume, define remediation areas, and evaluating what areas to address based on cleanup goals. There are also a number of quality assurance checks including estimation error and cross-validation of the modeling and other interpolation methods.

Final products from the decision support analyses include screening level risk analyses; maps, analyses, and reports; and pre- and post-remediation comparisons regarding achievement of cleanup goals. These outputs support communication with decisionmakers.

Initial Sample Designs

Dr. John Kern, with Kern Statistical Services, Inc., provided an overview of sampling designs developed and/or implemented on various contaminated sediment projects as well as those strategies that appear to work best for decisionmaking. A number of reports challenge the

effectiveness of dredging as a remediation technique yet failure to sample properly or the failure to properly delineate the contamination may result in this outcome in addition to the dredging technique itself. A 2001 National Research Council report noted that a contributing factor is leaving untargeted sediment deposits in place. Sampling generates data that support delineation of the target areas requiring remediation, therefore, proper sampling design will minimize the potential for this problem to occur.

Drawing on an analogy in mineral exploration, there are two sampling phases—a broad exploration phase and more focused (smaller scale) sampling of specific deposits intended for development using 20-foot borehole spacings. Extrapolation of this approach to contaminated sediment studies raises the concern that to identify contaminants present in much lower concentrations than found in mineral exploration, it may be necessary to sample on a smaller scale or to change the decision process. In mining, the decision area is small and contains many samples, while in sediment remediation, the area tends to be large with fewer samples. Where large transects are used in sampling design, the lack of resolution may limit the utility of the collected data.

Objectives to design for include ecological and human health risk assessment, presence or absence of contamination, nature and extent of contamination, baseline quantification, volume and mass estimation, fate and transport modeling. The initial sampling phase is important because it tends to form the basis for all future investigations. Investigations beyond the remedial investigation/feasibility study stage, such as for remedial design and implementation, require more detailed information. This is similar to the second phase of mineral exploration and likened to a high density, in-fill sampling approach. Finally, long-term monitoring is a completely different objective; however, these data must comparable to the initial sampling data in order to determine if the remedial action is performing as intended on a long-term basis. Often the first phase of design is haphazard, biased, and judgmental and later arises the question about how to compare monitoring data to initial results in a meaningful way.

Remediation projects often stall between the remedial investigation/feasibility study and remedial design phases, and this often involves disagreements over data adequacy. One approach may be to use the more “global” data to complete the remedial investigation/feasibility study process, then include short-term sampling to delineate the areas to address during the design phase. A decision chart illustrated such an approach. Use of a systematic sampling design will also help with subsequent data analysis and comparability with future data. In addition, addressing the question of whether the data are sufficient to conduct a cost-effectiveness analysis may be another decision point on whether to proceed to design; this translates into a “denser” sampling design at this stage of the remediation process.

An overarching recommendation was to invest in the initial sampling phases because the sample data collected early in the Superfund process affect discussions for the life of the project, and the impact of a poor design will be multiplied with time. The long-term cost of arguing over data adequacy and validity is likely to be greater than the cost of collecting good data at the outset. Of final note, each project may require a different design approach.

Several examples were explored to demonstrate the sampling design principles discussed in this session. A contaminated sediments project on the Kalamazoo River in Michigan showed that

more than doubling the sampling (data) density confirmed earlier estimates and increased resolution for the feasibility analysis. Optimization of the remediation decision should consider the cost of sampling, moving clean material, and failure to properly target contaminated areas.

Another example addressed the use of a double sampling technique on a Michigan project. There are physical variables that are easier and less expensive to measure than contaminants and may be used correlate or extrapolate to contamination if a relationship between the two exists. This can minimize analytical cost and generate data adequate to estimate large-scale parameters such as volume/mass of contaminated sediments and average surface concentrations.

A third example involved infill sampling of contaminated soil at a lead smelter in Dallas. On consideration was where to use this technique. Since the actions necessary to address areas where the contaminant concentration is above cleanup goals or very low are known, infill sampling is most useful in areas where concentrations are near thresholds for risk.

General recommendations were to use biased sampling initially to confirm if it is worth the time and expense of doing something significant at a site, followed by broad-based, systematic, unbiased sampling to get even coverage over the site and to get at the large scale parameters such as mass and volume. In conjunction with statistical evaluation of data adequacy, targeted infill sampling can be used to refine/update final design and implementation followed by confirmation sampling (might be the most dense sampling network of any remediation phase), then broad-based long-term monitoring to evaluate performance similar to initial sampling.

Spatial Estimation

Dr. John Bing-Canar, with EPA Region 5, discussed the methods used for spatial estimation (e.g., contouring) in the study of contaminated sediments. Spatial estimation involves a number of methods to generate estimates for unsampled locations, and these estimates are functionally dependent upon the surrounding data. The estimated values from spatial estimation support the development of visualizations, aid in secondary sampling design, estimate mass and volume of contaminated material, support decisions on areas to cleanup, and evaluate changes in sediment surface over time including post-dredging evaluations.

Dr. Bing-Canar also discussed exploratory data analysis (EDA), which uses descriptive statistics to examine extreme values, outlier tests to determine data acceptability, and spatial duplicate values and how to use it, limit of detection (e.g., value to use for “not detected”), and coordinate transformation (e.g., “straightening” to represent a relationship in true space). The FIELDS system includes an algorithm to check and address values for spatial duplicates and has transformation algorithms.

Many spatial estimation methods involve interpolations such as weighted or moving averages. In general, these apply some weight to original data to create an estimate for a particular sampling location. Commonly used spatial estimation methods include Inverse Distance Weighting, Natural Neighbor, and Kriging among others. The differences are in the weighting. For Inverse Distance Weighting, weights are inversely related to difference; points close by are given greater weight than those farther away and directionality is not a factor. For Natural

Neighbor, weights depend on the geometric area around each data point. For Kriging, weights derive from spatial correlation.

A consideration in conducting spatial estimation or interpolation is cell size. The smallest cell size is the size of the sampling core. It is best to use as small a cell size as possible because larger cell sizes smooth the data and may misrepresent the information.

Data transformation can also influence the data representation unless the proper correction is applied.

Geostatistics are a set of mathematical tools that describe (model) the spatial correlation of data and make predictions about these data using Kriging, which can create a standard error to understand the precision of the estimate. Geostatistics can also be used to look for directionality. Often, especially in a riverine or harbor environment, the sediment contamination tends to follow water flow. Another use of geostatistics is to evaluate the "dis-similarity" between data separated by a distance. The natural logarithm is often taken of the original data and used for analysis because it tends to "tighten" the information and make it easier to fit curves.

Model validation helps to determine confidence in the interpolation. Cross-validation is a pre-estimation method used for validation. Another method is to estimate error by determining the difference between each original value and its respective interpolated value. Most important to evaluate is where estimates are made between measurements rather than the measurement itself. Other methods include data splitting and bootstrapping.

Take home messages are that it is just as possible to "lie" in data interpretation/analysis with interpolation as with statistics. To avoid this, it is important to know exactly how the spatial estimation was performed, what was done with the data before it was interpolated (e.g., data pre-processing such as duplicate handling and data transformation), what interpolation method (algorithm) was used, what parameters were used (e.g., number of neighbors, search radius), and any other assumptions such as which areas were not interpolated or were excluded from analysis. Spatial estimation (regardless of technique) is just as liable to all the limitations inherent in prediction. There is no such thing as giving the exact answer.

Of final note, insufficient data or highly clustered data lead to poor, misleading, and/or inaccurate estimates; therefore, when to say "no" to proceeding with insufficient data for analysis and requiring additional data collection is important. In addition, use of secondary sampling is recommended such as adaptive fill and radials to quantify spatial correlation.

Decision Analysis

Mr. Charles Roth, with EPA Region 5, discussed decision analysis tools and their application to support remediation decisionmaking. There is a need to start using more sophisticated methodologies such as FIELDS not only to help with data analysis and decisionmaking, but also because the potentially responsible parties are using more of these techniques. The decision analysis tools of FIELDS provide information to decisionmakers in a useful form and the results are repeatable by others. All the work is based on generating information that someone will use.

There are several decision analysis tools available. Maps are one such tool and are useful to understanding the extent of contamination and areas requiring remediation, which are easier to see than explain. Thus, maps can be very powerful communication tools. In one glance, the problem and its extent can be understood. This is useful in public presentations as well as in support of more detailed analysis of vertical contamination.

Data analysis focuses on important end products such as average concentration, volume of contaminated soil/sediment, contaminant mass, and cleanup curves for decisionmaking as well as pre- and post-remediation comparisons (e.g., were goals met). This enables identification of areas above specified concentration levels and the conduct of mass/volume comparisons to determine the need for different concerns/approaches to address contaminant variation by layer in the subsurface. Ecological and human risk assessments provide a range of values that are protective, and cleanup curves can be generated to help the decisionmaker assess action levels and which techniques are most effective in consideration of cost and other factors. In addition, how much a site costs to cleanup depends upon how much volume must be cleaned up, and the contaminant mass helps in understanding the extent of cleanup achieved and evaluate reductions in average contaminant concentration. Also, mapping mass estimates can help decisionmakers address how to remove a specified percentage of contaminant mass.

Tools available to help risk assessors with the human health and ecological risk assessments include computer models to support human risk analysis, and algorithms to evaluate contamination data in conjunction with levels that produce harm mapped to habitats to determine impacts. There are also tools to estimate exposure over time.

There are also tools useful for pre- and post-remediation to follow cleanup progress, assure cleanup goals are met, and supports continued monitoring of ecosystem recovery. These tools provide a standardization of the process and demonstrate that any variability found is not due to analysis methods.

Additional information on FIELDS and the associated analytical tools is available at: www.epa.gov/region5fields and www.tiem.utk.edu/~fields.

Section V: Year of Water—30 Years of Progress Through Partnerships

Tuesday and Wednesday, May 6-7, 2003

The purpose of this breakout session on the second and third days of the meeting was to focus on human impacts on water systems, ecological and human health implications of impaired systems, improved tracking and monitoring of water system degradation, improvement in overall water quality, the relationship between drinking water and waterborne disease, and EPA partnerships with state, local, and tribal governments on a variety of local and overarching water issues. Each session included opportunities for a panel discussion and to respond to audience questions that provided additional information and insight on a variety of water-related topics.

Dr. Fred Hauchman, with NHEERL, led a session addressing the implications and prevention of waterborne disease in drinking water. Presentations included efforts to estimate the occurrence of waterborne disease, implications for high risk, susceptible subpopulations, and the sources and control measures for microbial contamination during drinking water distribution.

Ms. Katie Flahive, with the Office of Wetlands, Oceans, and Watersheds (OWOW), led a session addressing the science of hypoxia and steps being taken to address the hypoxic region in the Gulf of Mexico. A panel discussion presented an overview of hypoxia, the contribution of freshwater rivers feeding into the Gulf of Mexico, and recent reports on the causes and potential solutions. A separate presentation addressed the creation and implementation of an Action Plan to reduce, mitigate, and control hypoxia in the Northern Gulf of Mexico.

Mr. Michael Slimak, with NCEA, led a session addressing the threats posed by invasive species and diverse actions underway to prevent their introduction and control those already present. Presentations included regulatory initiatives and partnerships to address the pathways for invasive species introduction, highlights of USCG research activities, efforts to develop an international treaty, the use of an electric barrier to control the spread of Asian carp, pesticide control programs related to the management of invasive species, and precautions for prevention actions derived from historic toxic chemical usage.

Mr. Bill Hirzy, with the National Treasury Employees Union, and Ms. Roberta Baskin, a Senior Reportor, led a session addressing the arguments for and against the national policy for fluoride addition to drinking water. Presentations included an overview of drinking water regulations and

the health benefits of fluoride addition to drinking water as well as a counter viewpoint on the necessity for a national water fluoridation policy and health consequences of fluoride ingestion.

Mr. Kenneth Potts, with OWOW, led a session addressing current issues in coral reef management and initiatives to develop biological indices to reduce ecosystem stressors locally and globally. Presentations included human-induced and natural stressors on coral reef health, regulatory strategies to develop and incorporate biocriteria pertinent to coral reefs, and the development and application of indicators to provide early warnings of adverse changes to coral reef health.

Mr. Jamal Kadri, with the Office of Water, led a session addressing initiatives and tools to protect and restore watersheds from the impacts of population growth. Presentations included Smart Growth principles and their application to watershed planning and restoration, impervious cover as an indicator for watershed quality, and the use of partnerships and community roundtables to aid in watershed protection.

Ms. Susan Holdsworth, with OWOW, led a session addressing innovative sampling methods and data analysis techniques to identify stressors and to assess watershed condition in support of decisionmaking. Presentations included the utility of biological indicators, the use of probabilistic sampling and monitoring strategies, and a desktop tool for rapid, desktop wetlands assessment.

Mr. Joe Hall, with OWOW, led a session addressing the increased use of volunteer monitoring efforts in support of wetlands, coastal, and estuarine programs. Presentations included an overview of volunteer monitoring activities, partnerships and tools supporting volunteer monitoring for wetlands, volunteer monitoring and information sharing in support of estuary and coastal condition evaluations, and future challenges and opportunities.

Waterborne Disease in the United States

Following opening remarks by Dr. Fred Hauchman, with NHEERL, three speakers addressed waterborne disease trends and factors affecting microbiological contamination of drinking water. Question and answer sessions occurred at the end of each presentation and at the end of the session.

Dr. Fred Hauchman, with NHEERL, noted that safe drinking water can only occur the source is protected. Dr. Hauchman outlined how this session on waterborne disease would progress mentioning that this was one of the few drinking water programs scheduled. Dr. Hauchman discussed EPA's strong partnership with the CDC in the areas of waterborne disease and drinking water monitoring.

Drinking Water Related to CWA Endemic and Epidemic Waterborne Disease: An EPA and CDC Partnership

Chief of the Epidemiology and Biomarkers Branch at NHEERL, Dr. Rebecca Calderon, reiterated the importance of the EPA-CDC collaborations, which include waterborne disease surveillance and outbreak investigations. EPA also maintains an official database of waterborne diseases dating back to 1971. Dr. Calderon differentiated between endemic and epidemic diseases, defining an epidemic as an increase above the background rate of illness. An outbreak usually occurs when at least two persons are diagnosed with a similar illness; however, cases of *legionosis* are not included in the identification of an outbreak.

Epidemiological evidence must implicate drinking water in order to classify an outbreak as a waterborne disease. Common drinking water micro-organisms that may cause gastrointestinal illness include *Giardia*, *Shigella*, and the Norwalk virus, which is famous for its effects onboard cruise ships.

Detection of an epidemic occurs when someone is in the right place at the right time and puts all of the pieces together. Waterborne disease surveillance is a joint partnership with the states, but is a passive surveillance system in that EPA must wait for states to report back. States are the ones investigating and reporting incidences of disease, which leads to inconsistency of reporting and underreporting.

Examination of drinking water disease outbreak trends over the last 30 years reveals a big increase in drinking water-related disease outbreaks in the early 1980s. During this time, a tremendous amount of infrastructure was put into place in state and local systems, which may have led to contamination. As infrastructure systems are updated in the next decade, we may see another such increase. The trends show drinking water disease outbreaks declining as the drinking water regulations work to zero out contamination of drinking water supplies. Within 10 years, a similar trend is expected to be seen for groundwater as a result of up and coming regulations.

Drinking water intervention can occur either at the community level through the upgrade of treatment before the water is distributed or at the household level by increasing the quality of

water in the home. EPA has typically conducted household intervention studies. Three studies involve 300 families recording daily diaries of incidences of diarrhea and vomiting, as follows:

- Community I: October 1995 to January 1999, completed
- Community II: September 1999 to December 2001, currently evaluating data
- Community III: January 2003 to June 2003, in the last stages of the experiment

The results of the Community I study indicate a decrease of approximately 30 percent in gastrointestinal illness rates that is most likely attributable to increased quality of water. Water quality testing for parasites showed no real change with parasite population counts remaining negative the entire study. However, there was a drop in heterotrophic plate count and turbidity. There was also a significantly lower rate of gastrointestinal illness in children, but hospitals did not report lower rates of illness. *Cryptosporidium* showed no change leading researches to believe that *Cryptosporidium* is not a significant drinking water contaminant in that community.

An analysis of household intervention studies indicates that all systems met United States drinking water standards after treatment. The first study reported that 35 percent of microbial gastroenteritis is attributable to water, and the second study reported that 14 percent of microbial gastroenteritis is attributable to water. An Australian study showed similar results. The results from an Iowa study are still pending.

There is a need for a national estimate of waterborne diseases. However, this has not been easy to identify. Two components of a national estimate include the population attributable risk (illness due to drinking water exposure) and the incidence of acute gastrointestinal illness. In 1998, Foodnet conducted telephone surveys to identify background rates of illness for diseases from all causes. Three rounds of surveys were conducted for a total of 32.2 million people surveyed (12 percent of United States population). This survey found that 1 in 12 persons seek medical care.

Epidemic studies continue to examine waterborne disease outbreaks, emerging micro-organisms (e.g., *Cryptosporidium*), and water treatment technology/operations. Endemic intervention studies show that water treatment improvements can reduce diarrheal disease. Future research collaborations include:

- Continuing to investigate and evaluate epidemic levels
- Preparing water security
- Developing an N1 estimate of waterborne diseases for endemic levels
- Examining the distribution system
- Focusing on susceptible populations.

When asked about any international considerations/partnerships, Dr. Calderon explained that EPA has had meaningful discussions with Mexico. Mexico is better about collection of data and reporting for diarrhea and vomiting. The challenge is obtaining access to the data, as Mexico is currently unwilling to provide such access. EPA will continue to work with the Mexican government to improve informational sharing. There also is a tremendous effort underway to

improve the infrastructure in Mexico with EPA sponsorship of supporting programs, such as the Border 20-12 program.

A question also arose regarding sensitive subpopulations in the first contaminant intervention study. While the study did not specifically consider individuals with compromised immune systems, the trends for the elderly looked similar to those for children. Both the elderly and children are high-risk populations. However, the risk for children decreases as they approach adolescence.

Using Randomized Trials to Study Waterborne Pathogens Among Susceptible Populations

Associate Professor of Epidemiology at the University of California, Berkeley, Dr. Jack Colford, presented a study of drinking water intervention in susceptible subpopulations, specifically human immunodeficiency virus (HIV)-positive populations to develop an estimate of risk of gastrointestinal illness attributable to drinking water. Prior research indicates that anywhere from 0 to 40 percent of gastrointestinal illness can be attributed to drinking water intervention and up to 85 percent of the cases of cryptosporidiosis could be attributable to drinking water.

Prior to this study, randomized drinking water intervention trials had not been conducted for HIV subpopulations even though drinking water is a concern for this subpopulation. This was a randomized, triple blinded home intervention study that included 50 individuals. Participating individuals were provided with a water filtration device installed in their home (attached to the faucet) and participants filled out a daily diary for 16 weeks. The study was a triple blinded trial in that neither the participants, the investigators, nor the statisticians/data evaluators knew which home received an active or dummy water filtration device. The "blinding" of the participants was done in order to prevent any personal sense of what their own health should be when reporting. The success of blinding is measured by a blinding index, with scores ranging from zero (worst case) to 1.0 (perfect) and 0.5 being an acceptable score.

Ninety percent of the initial participants completed the study (89 percent who had an active device and 97 percent who had the dummy device). A highly credible gastrointestinal illness (HCGI) requires that there be six disease free days between episodes before an illness can qualify to be measured. The results are as follows:

- Dummy devices—31 HCGI episodes, 6.3 episodes/person/year
- Active devices—16 HCGI episodes, 4.0 episodes/person/year
- Odd ratio of illnesses (Dummy vs. Active)—3.3 episodes/person/year.

The results had a blinding index of 0.62 indicating that the majority of the individuals were unable to identify which device they had been given.

While this study is not large enough to make recommendations based on the results, this does demonstrate the feasibility of conducting these types of trials, the findings are consistent with findings presented in prior research findings, and if large enough, future studies could have an impact on drinking water habits.

When questioned about drinking water research priorities in the future, Dr. Colford recommended a focus on (1) smaller, well-done studies as big as they can be rather than larger time-series studies, (2) more specific pathogen identification, and (3) target susceptible populations. When asked what study size would prove large enough to support recommendations, a tentative number of about 150 was suggested.

Maintaining Microbiological Quality of Drinking Water in the Distribution System

Director of Research at American Water, Dr. Mark LeChevallier, discussed monitoring to maintain the biological integrity of water distribution systems to ensure that high quality water from a treatment plant maintains that quality in distribution and receipt. The first concern is how microbes enter the system – by growth or through distribution system contamination. Studies based on *coliform* control show a complex interaction of factors related to regrowth:

- Filtration
- Temperature (the summer months are more problematic)
- Disinfectant type and residual
- Assimable Organic Carbon (AOC) and Biodegradable Dissemblic Organic Carbon (BDOC) levels
- Corrosion (a potentially large factor as it provides an area that may protect bacteria from disinfectants)
- Characteristics of the distribution system.

Mycobacterium Avium Complex (MAC) occurs in water supplies and includes *M. avium and M. intracellulare*. MAC is resistant to disinfection and regrows in biofilms. Disinfection studies show that MAC is hundreds of times more resistant to chlorine than *E. coli*. Individuals with compromised immune systems are at the greatest risk, and MAC has been documented in Boston and San Francisco, both of which are areas with large immunocompromised subpopulations.

Current water treatment is capable of removing MAC. Research indicates lower MAC levels in the distribution system near the treatment plant with levels increasing later in the distribution system. Research demonstrates that rates of gastrointestinal illness are lower near the treatment plant.

There are three ways to control MAC: (1) reduce turbidity, (2) reduce nutrients, and (3) heat treat the water. Increases in *M. avium* levels correlate with elevated AOC and BDOC levels; therefore, reducing nutrients in the water would decrease the presence of *M. avium*. Groundwater has lower levels of AOC because the water percolates through the ground removing much of the AOC. When water temperature is increased to 52 degrees Celsius, there were no *M. avium* detected in the water (>99.9 percent inactivation). This indicates that a good treatment option for *M. avium* may be to flush the system with hot water.

Surge analyses show that anything with the potential to quickly stop water flow in the distribution system (such as service interruptions, sudden changes in demand, and distribution system operation) can cause pressure transients resulting in pressure waves traveling through the distribution system. These surges may produce negative pressures and hydrologic surge waves may be additive thereby increasing the stress on the distribution system. At times of negative pressure, microbes may enter.

The amount of separation between water distribution and sewer lines is also of concern due to the potential for microbes to migrate between pipelines from leaks or breaks. Typical separation distance is 10 feet, but standards allow for a minimum of 18 inches of separation. Research has identified a correlation in the winter months between the number of leaks repaired and an increase in coliphage concentrations.

Maintaining water quality in the distribution system will dominate drinking water concerns of the next decade. More information is needed on pressure transients and the determinants of regrowth. Also needed are ways of measuring residual effectiveness for intrusion control, and a better understanding of the system characteristics leading to intrusion.

When asked about the importance of the home distribution systems (pipes, etc.), the ratio of surface area to volume was noted as important for growth of pathogens. In the water distribution system, a large ratio between volume and surface area decreases the likelihood of contamination. Cross-connections typically found in households significantly increase the risk of contamination. There is usually higher surface area in homes relative to the distribution system resulting in a greater opportunity for contamination in the household systems. Older homes have copper plumbing systems and now the standard is to use polyvinyl chloride (PVC) piping. Both materials, relative to biofilm growth, have advantages and disadvantages. The plastic surface of PVC allows for disinfectants to be more effective. Using heat treatment with copper pipes requires a lower heated water temperature to inactivate biofilm than for PVC. Therefore, the relative importance of the material of the home distribution system depends on which treatment methodologies are preferred.

Panel Discussion/Questions and Answers

The speakers had an opportunity to participate in a brief panel discussion drawing on questions from the audience.

A brief question and answer period addressed a single topic involving potential differences between rural and urban areas in waterborne disease outbreaks and the absence of studies on small populations.

Mississippi River Basin Hypoxia

Following opening remarks by Ms. Katie Flahive, with OWOW, a panelist discussion addressed the science of hypoxia and the session concluded with a presentation on the steps being taken to mitigate hypoxia.

Ms. Katie Flahive, with OWOW, introduced the panel discussion participants: Mr. Lee Mulkey, Associate Director for Ecology at the National Risk Management Research Laboratory (NRMRL); Dr. Mary Belefski, with OPPTS, and Dr. Rochelle Araujo, Associate Director for Ecology at NERL. Ms. Flahive also briefly introduced the concern of hypoxia in the Gulf of Mexico as the basis for the panel discussion.

Hypoxia in the Gulf of Mexico

Mr. Lee Mulkey initiated the panel discussion by providing an overall perspective for the concern over hypoxia using the Gulf of Mexico as an illustrative example. The Gulf of Mexico drainage area is equivalent in size to two-thirds of the land area of the United States. After dealing for many years with point sources of water pollution (e.g., water treatment plants, industrial plants, etc.), there now exists a dominant non-point source problem, and there is much difficulty encountered in identifying the sources of nutrient loading into freshwater river basins. Estuaries, in turn, are extremely vulnerable because freshwater rivers are discharging large amounts of nutrients into these areas. The eutrophication process in estuaries is recognized as a national problem. Increased nutrient loading leads to an increase in biological productivity and results in an increase in organic matter, which in turn leads to dissolved oxygen depletion and the hypoxia problem.

Non-point sources in the Midwest are contributing excess nutrients to the freshwater rivers feeding into the Gulf of Mexico, therefore the hypoxia problem becomes a transboundary issue. There is an inability for the source to internalize the costs making this an area ripe for bringing in social sciences and to look at free market solutions. Assistant Administrator Tracy Mehan is very interested in examining the solutions that a free market model may bring. Modeling and sampling continues in hypoxia region within the Gulf of Mexico, and EPA's EMAP is collaborating with state and local programs to work towards solving the hypoxia problem. This is *the* water quality challenge. The questions regarding who pays and how to resolve this equitably remain unanswered.

Dr. Mary Belefski identified six key reports related to the science of hypoxia:

1. Committee on Environment and Natural Resources of the Office of Science Technology Policy – Characterization of Hypoxia: Nutrient Loading ratios in the Gulf of Mexico. This was a heavily peer-reviewed scientific study of the hypoxia zone.

2. Ecological and Economic Consequences of Hypoxia. This report examined the economic consequences in other hypoxic areas in the world such as the Black Sea. An economic loss due to hypoxia in the Gulf of Mexico is not being seen because there has not been a change in fish harvesting rates. Current science does not enable identification of how current hypoxic conditions in the Gulf of Mexico compare to the historic stages of hypoxia development in the Black Sea, which makes it difficult to predicts potential economic losses for the Gulf of Mexico and when those may occur.

3. Flux and Sources of Nutrients in the Mississippi-Atchafalaya River Basin. This report presented a study involving a mass balance analysis of nutrients (nitrogen and phosphorus)

and the flux of these nutrients into and out of this river basin. This study found that 90 percent of the nutrient sources now come from non-point sources.

4. Effects of Reducing the Loads to Surface Waters within the Mississippi River Basin and Gulf of Mexico. A University of Minnesota professor in collaboration with others examined nutrient loading models to answer the question as to what would happen if nutrient loads were reduced.

5. Reducing Nutrient Loads, Especially Nitrate-Nitrogen, to Surface Water, Groundwater, and the Gulf of Mexico. This study examined the methods to reduce the nutrient load with an emphasis on restoring wetlands in the watershed to act as filtering mechanisms. This study also considered the impacts of changing agricultural practices to reduce loading.

6. Evaluation of Economic Costs and Benefits of Methods for Reducing Nutrient Loads to the Gulf of Mexico. This study evaluated the costs to implement the load reduction programs as identified in the report in Item #5, above.

NOAA has published all the reports on its website at:
http://www.nos.noaa.gov/products/pubs_hypox.html.

Action Plan for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico

Ms. Katie Flahive, with OWOW, presented the Action Plan for Reducing, Mitigating, and Controlling Hypoxia in the Northern Gulf of Mexico (2001) that was developed through collaboration of nine Federal agencies, nine states, and two tribes. The Action Plan is designed to work on a basin-by-basin basis.

In 1985, the first measurements of the hypoxic zone in the Gulf of Mexico were recorded. Published articles and public notifications increased public awareness of the problem. In 1996, EPA convened the Federal Principles, which proved to be the background for a task force. The task force has met nine times since 1997, and is open to public comments. In 1998, Congress passed the Harmful Algal Bloom legislation and Hypoxia legislation. The Action Plan was then developed and published in January 2001. The task force conducted an analysis of point source loading to the region and estimated that annual nutrient discharges for total nitrogen and phosphorus were occurring from 11,500 point source facilities. With nine river basins included in the scope of concern, the Ohio River valley and middle Mississippi River valley are major areas of concern for nitrogen.

The collaborative principles of the task force are to: (1) improve the scientific understanding of hypoxia causes and solutions by increased monitoring throughout the basin, (2) maintain national focus on the basin and increasing communication between the public and scientific community for an overall behavior change in the basin using the Chesapeake Bay area as a model, (3) address voluntary and practical “win-win” projects for local impairments and the larger hypoxia problem, and (4) provide measurable outcomes, parallel sciences, and adaptive actions.

The size of the hypoxic zone is increasing each year. In 2001, the Mississippi–Atchafalaya River Basin hypoxia zone was larger than the size of Chesapeake Bay. Trends indicate that the hypoxic zone is growing as normal rainfall continues year by year, and that it is nearing the size of Lake Erie. A 5-year running average estimates the size at 14,000 square kilometers.

The task force developed three goals to address these changes:

- Coastal goal to reduce the size of the hypoxic zone to less than 5,000 square kilometers by 2015

- Quality of life goal to improve community and economic conditions across the Basin

- Basin goal to restore and protect the waters of the 31 states and 77 tribes in the Basin.

The task force is committed to 11 actions of which the most notable are to develop another budget proposal this year, to get all sub-basin committees running (currently at about half), to develop a pilot trading program to reduce nitrogen loading from point sources throughout the Basin via voluntary actions, to use farm bill funds to support assistance to landowners and agricultural producers, and to assess in 2005 and every five years thereafter the results of these actions, leading to the goal of reducing the hypoxic zone to less than 5,000 square kilometers by 2015.

More information on the trading program is available at www.nutrientnet.org and at http://www.envtn.org/.

Panel Discussion/Questions and Answers

The speakers had an opportunity to participate in a brief question and answer session with the audience.

A brief question and answer period addressed a range of topics. These included: (1) the behavior changes that led to reduced nutrient loading in the Chesapeake Bay; (2) utility of mandatory nutrient management plans required but a few states to reduce nutrient loading and the need for sub-basin areas to work together; (3) incorporation of lessons learned from trading programs in Connecticut and New York and the challenges of integrating non-point sources into such programs; (4) wastewater treatment plants as main sources of nutrients; and (5) credit recipients of trading programs (farmers, producers).

The Millennium Challenge: EPA's Response to Invasive Species

Following opening remarks by Mr. Michael Slimak, with NCEA, and Ms. Marilyn Katz, with OWOW, six speakers addressed diverse Federal and international initiatives to prevent, manage, and control invasive species. A panel discussion including an audience question and answer period followed the presentations.

Mr. Michael Slimak, with NCEA, provided opening remarks and defined invasive species as non-native species, plants, animals, and microbial pathogens that harm the environment, public

health, agriculture, and industry. Scientists, business leaders, and natural resource managers acknowledge that invasive species are among the most serious ecological, human health, and economic threats of the 21st century. Invasive species infest every state and affect everything from biodiversity to grazing and agricultural lands. In 1993, a report by the Office of Technology Assessment concluded that a lack of interagency cooperation was a significant barrier to addressing the threat posed by invasive species. This report led to Executive Order 13112, which established the National Invasive Species Council. The cost of invasive species exceeds $100 billion annually in the United States and ranks with habitat loss and fragmentation as among the most critical threats to maintaining ecosystem integrity.

Partnerships are essential to deal with the problems posed by invasive species. EPA is an active partner of the National Invasive Species Council, and has helped to establish the National Invasive Species Management Plan. Additionally, EPA is a member of the Aquatic Nuisance Species Task Force established to coordinate efforts to combat non-indigenous aquatic species in the United States. EPA is an active partner with other agencies in the war on invasive species and looks to use regulations, better information, research and monitoring, and other measures to help combat this complicated problem that does not have an easy solution.

Ms. Marilyn Katz, with OWOW, introduced the session speakers.

The Office of Water Perspective

Assistant Administrator for the Office of Water, Mr. G. Tracy Mehan III, provided the Office of Water's perspective on invasive species. Historically, EPA may have not had a large role in this issue; however, this is changing as EPA looks to combat biological threats. Paraphrasing a statement by Dr. Bill Cooper, the biggest risk to the integrity of the fauna and flora of the Great Lakes is not toxic substances, but invasive species. A greater return may be achieved by allocating investments to combating invasive species than to the incremental cleanup of toxic substances. The future will focus on ecological risks rather than the human health side.

Controlling invasive species is a costly endeavor as evidenced by the 50 years of control of the sea lamprey, which entered the Great Lakes through the St. Lawrence Seaway. This low-level control program has resulted in tens of millions of control costs, and is the basis of the entire fishery system in that region. Zebra mussels and the spiny water flea are two additional examples of invasive species in the United States. Approximately 160 such invasive species have entered since the opening of the St. Lawrence Seaway and from ballast water discharges. Predictions based on shipping patterns identify the potential for 17 new introductions of invasive species from the Baltic and Caspian Sea alone. The possible entry of the Asian carp into Lake Michigan is of current concern. The massive scope of these challenges presents a tremendous threat to the waters of the United States, and the threat of invasive species ranks only second to the loss of habitat. Over 500 invasive species inhabit the coastal and marine habitats of North America.

Efforts taken by the Federal government are encouraging. This is being viewed as a watershed management issue with invasive species, both aquatic and terrestrial, as integral parts and threats that need to be addressed. The "principal of prevention" may need to be applied; once these species are established, they are here forever, and at that point the best that can be done is to

focus on integrated pest management. As a result, there is a need to focus on preventing the introduction of invasive species through the key vectors for introduction, which is ballast water for aquatic invasive species. A large toolbox or toolkit is needed due to the massive scope of the challenges and because the threat is multifaceted. Five areas of activity are of immediate focus:

- Prevention—working with partners such as the United States Fish and Wildlife Service and the USCG
- Rapid response and monitoring—the Australians have been leaders in this area
- Controlling and managing the invaders—necessary, but the also the least preferable approach as it is after-the-fact management
- Education and outreach—to inform the public of the magnitude of this concern
- Leadership—show by example that invasive species control is a priority and place invasive species near the top of the list of threats.

Ballast water is critical in the Great Lakes as well as the coastal areas, and this needs to be better understood and controlled. The ETV Program is involved in the identification of new technologies to assist in the fight against invasive species. EPA also plans for more research investment in this area, as it is the "preeminent environmental issue."

United States Coast Guard Research: Research in Support of the Coast Guard's Program to Prevent the Introduction of Nonindigenous Species by Ships

Dr. Richard Everett, with the USCG, provided highlights of research conducted by the USCG related to invasive species, research results, and initiatives to actively combat invasive species entry routes using new technology, regulations, and best management practices. Since the USCG is not a basic science research agency, all of the USCG research directly supports basic operations or its regulatory activities. Research has identified that the magnitude and relative importance of ship-mediated invasions has increased, and an increase in regulations and controls in this area should be expected in the near future.

The ship-mediated vector includes the following pathways for invasive species introduction: ballast water discharge, hull fouling, prop fouling, sea chest fouling, and the chain and locker. The main types of ships responsible for ship-mediated invasions include passenger vessels/cruise ships, container ships, and tankers. Each type of vessel discharges different quantities and qualities of water. On average, tankers discharge the largest amount of ballast water (over 10,000 cubic meters), with passenger ships discharging the least amount (only a few hundred cubic meters of water). Rates of discharge and the age of water differ by ship type as well.

Legislative directives such as the National Aquatic Nuisance Prevention and Control Act (1990) and the National Invasive Species Act (1996) have directed the USCG research to address the ship vector and invasives. NISA created the National Ballast Information Clearinghouse that requires reporting from all vessels with foreign ballast water. USCG regulatory activities require

all vessels to report outside of 200 miles, and require all vessels to conduct active ballast water management. This may lead to establishing a quantitative ballast water discharge standard.

Verification of ballast water exchange is a research priority. In the Great Lakes region, salinity is used currently to verify that ballast water exchange has occurred. Research partners include the Smithsonian Environmental Research Center and international agreements.

There is both a national and international effort to develop a discharge standard. A percent reduction standard is under consideration, but this may prove problematic due to the difficulty in identifying the initial biotic composition of the water.

Treatment of ballast water is a challenge because ballast water flow rates are very high (approximately 2,500 cubic meters per hour) and a wide range of organisms in the water makes it difficult to establish a universal standard. The USCG is working in partnership with the EPA ETV Program to identify technologies that will assist in ballast water monitoring and treatment.

International Treaty Effort to Address the Transfer of Invasive Species Via Ballast Water

Ms. Kathy Hurld, with OWOW, presented the international perspective on invasive species, progress toward the development of an international ballast water treaty, and the challenges in keeping the treaty in line with the goals of the United States. Currently, there are no standards, no available technologies, and many questions that still need to be answered, yet the regulatory process must move forward. An international ballast water treaty is necessary because ships travel internationally and most ships are not registered in the United States, rendering any United States regulations useless. A ballast water treaty will help to protect biodiversity and provide a balance between commerce and the environment. There are many Federal agencies working toward developing the treaty via an interagency working group to identify objectives important to the United States, which include the following:

- Setting standards stringent enough to drive technology
- Basing the treaty on sound science
- Setting verifiable, measurable, and enforceable standards
- Having everyone on board because it is an international effort
- Preserving the right of states with ports to take more stringent measures
- Preserving the freedom of navigation since port delays due to monitoring would be costly
- Completing the treaty in a quick timeframe.

The International Maritime Organization faces several challenges as discussions toward an international treaty move forward:

- Whether a standard be based on discharge or best available technologies

- The need to set a numerical standard based on concentration not percent removal

- Whether to set an interim standard and then move toward a final standard that is biologically meaningful

- How to sample in port without causing large delays

- The timing of when the treaty would enter into force (i.e., sooner vs. later)

- Applicability of the standard for existing ships and ships built in the future, and the availability of technology to set a standard for all types of ships, including passenger ships (a preference of the United States)

- Are we ready for a diplomatic conference where countries can sign a treaty?

The current timeframe includes a meeting in July 2003 of the Maritime Environmental Protection Committee of the International Maritime Organization followed by a diplomatic conference in February 2004. Uncertainty still exists as to when the United States will ratify the treating or when the treaty will enter into force. The principle objective is to have a treaty provide a vehicle that is compatible with United States goals and other Federal programs. The United States has successfully pushed for a discharge standard in the treaty and NISA is likely to be the implemented regulations. Every step of the process is being done through partnerships and that need to be maintained as efforts move forward.

A "Shocking" Solution for Controlling the Spread of Asian Carp into the Great Lakes

Dr. Marc Tuchman, Team Leader for both the Sediment Assessment and Remediation Team and the Invasive Species Team at the Great Lakes National Program Office (GLNPO), presented a localized, species-specific approach to controlling the spread of invasive species. The GLNPO is using an electric fence in the Illinois River to prevent the migration of the Asian carp into Lake Michigan. If the carp were to reach Lake Michigan, then management of their populations may be nearly impossible and the ecological damage would be significant.

Asian carp were imported into Missouri catfish farms for the purpose of cleanup, since they are planktovores, and involve three species:

- Big head carp, which is moving up the Illinois River towards the Lake of Michigan

- Silver carp from China, which can grow up to 100 pounds and have been documented as being able to jump out of water

- Black carp from China, which is used to clear snails out of catfish farms and can grow up to 70 pounds.

In the 1990s, Asian carp escaped the catfish farms as a result of accidental release and flooding, and the populations exploded in size. In a Missouri River fish kill, 97 percent of the fish were Asian carp and only 4 native species were found. Asian carp grow rapidly, consume large

amounts of plankton, out compete the native species, and disrupt the food chain. The State of Indiana has banned the transport, sale, and possession of the Asian carp. There have been reports that the Black Carp has escaped also, but this has yet to be officially confirmed. If this species was released, it may have the greatest impact since it also feeds on mollusks, which could potentially disrupt industries dependent on mollusks.

The Asian carp is well suited for the Great Lakes since they have temperatures similar to those preferred by this fish species. The question now is how to stop the Asian carp from entering the Great Lakes. Various prevention alternatives were considered, and an electrical organism barrier about 30 miles from Lake Michigan was selected as the most practical solution. The electrical barrier was designed by the United States Army Corps of Engineers and spans a 50-foot stretch of river. The sensitivity of electrical field was of concern, since the field would need to be strong enough for the fish to feel it and turn away but not strong enough to stun or kill the fish. Funding constrained the scope of the project, providing for a barrier with only a three-year life span. The barrier was constructed in April 2002 in an industrial area; therefore, barges serving the industrial area may provide a pathway for carp through the electrical barrier causing the efficacy of the barrier to be in question.

Monitoring activities in the area include the tagging of fish. Current predictions were that the first tagged fish would encounter the barrier in about six months. However, one tagged carp recently passed through the barrier, but uncertainty exists as to how this happened. As a result, the electrical field of the barrier was increased. A power surge shut down the electrical field for a day, so some fine-tuning of the barrier is required over the next four to five months before the Asian carp reach the barrier. A second barrier, with a 25-year life span, is being constructed about 1,000 feet downstream.

Introduced (Invasive) Species and Pesticide Control Programs

Mr. Daniel Rosenblatt, Team Leader for the Emergency Response Team with OPP, discussed the authorities of Federal pesticide laws and programs applicable to controlling the spread of invasive species and associated health considerations related to pesticide use. The two major pesticide laws are the FIFRA and the Federal Food, Drug, and Cosmetic Act.

FIFRA is the primary pesticide law, focusing on licensing of pesticides. FIFRA Section 18 contains a key exemption provision that provides the EPA Administrator with the authority to waive the pesticide use requirements in the event of an emergency. FIFRA Section 18 also allows for quarantine pesticide programs, which are often pursued on Plant Protection Act grounds by the USDA Animal and Plant Health Service. Some of the more common quarantine exemption programs include the use of Spinosad for the Mediterranean fruit fly (Med-fly) in Florida and California, the use of acetaminophen for the brown tree snake, the use of caffeine for the Coqui frog in Hawaii, and the use of Diquat to combat the snakehead fish in Maryland.

The Med-Fly Program uses border control and field detection in the high-risk, warmer, citrus-producing states such as Florida and California. In the 1980s, Tampa, Florida, and Los Angeles County started using the preventive release of sterile flies to combat increasing Med-fly populations. While this program has shown some degree of success in maintaining control over Med-fly populations, it is a very costly program. Other pesticide programs target adults and

immature life stages. In the event of an outbreak, chemicals are applied that are specifically targeted to each life stage. Regulatory control of host material is another measure used to combat invasive species.

The application of pesticides under the Med-Fly Program differs from other invasive species programs in that the objective is eradication rather than reduction. Outbreaks of the Med-fly are typically seen in populated or high traffic areas (airports, etc.), which increase the difficulty of pesticide application. In addition, there is disagreement regarding the best response method—ground versus air application. Additionally, community tolerance for pesticides varies by locality (Community Tolerance for Pesticide Exposure Variable) and provisions for advance notification to protection natural resources and sensitive persons are realities faced in the field.

The EPA role in exemption requests is to assess the aggregate risk, factoring in dietary risks, the bystander risk analysis, the occupational risk for the individual applying the pesticide, the impact on non-target species including endangered species, and the necessary response time. Key accomplishments in the Med-Fly Program include the adoption of a reduced risk pesticide, Spinosad, the ongoing sterile fly release in high-risk areas (California and Florida), and community participation in prevention programs.

In summary, the FIFRA quarantine exemption process is a key provision for EPA use on introduced and invasive species. EPA is responsible for preparing the risk assessment for quarantine uses of pesticides and the EPA Region provides field presence and technical support. There is an increasing national and bio-security aspect of the program as well. For example, the cleanup of the Hart Building and other buildings in Washington, DC, was based on a Section 18 exemption for a variety of decontamination chemicals.

Environmental Perspectives on Invasive Species Control: Precaution and Prevention

Ms. Jacqueline Savitz, Pollution Campaign Director and Senior Scientist for Oceana, reiterated the need for invasive species control programs using prevention of introduction as the crux for invasive species management and asked for careful consideration and precaution when introducing toxic chemicals into the environment as evidenced by past chemical uses. Before using toxic remedies, consider all unintended consequences to the extent that they can be anticipated, including long-term effects, fate and transport, protecting the integrity of the community structure, potential chemical interactions both additive and synergenistic, the low-level effects on non-target species (immune and reproductive systems), and the ability for the ecosystem to recover. Many examples were provided that illustrated the negative consequences and our history of chemical use gone awry.

When taking a precautionary approach, consideration of the non-toxic alternatives, prevention options, and remedy effectiveness are important. Prevention of invasive species introductions should be the primary course of action. Ballast water is the leading cause of aquatic species invasions, yet no mandatory controls exist except in the Great Lakes and implementation of those controls have not shown a change. Deliberate introduction of exotic species continues to be a widespread problem. New Zealand and other countries are using the precautionary principle to combat invasive species (e.g., flycatcher, anole, aphid-dogs, and seal pups-toads) and are not

allowing the introduction of any new species. Ballast water solutions include requiring mid-ocean exchange, onboard technologies, and onshore technologies. Mandatory requirements are also necessary to drive technology and use, and these needed to be set already. Oceana is working on cruise ships with technology that eliminates the need for cruise ships to uptake or discharge ballast water. This is an example of the "out-of-the-box" technology that is needed.

Two key take-home points are: (1) use precaution when applying chemicals because chemical use is never entirely safe, and (2) prevention of introduction should be the baseline for controlling invasive species. A credible prevention effort is needed along with careful consideration and precaution in the introduction of toxic chemicals into the environment. The overall recommendation is to not attack a millennium challenge with a bicentennial solution.

Panel Discussion/Questions and Answers

The speakers had an opportunity to participate in a brief panel discussion drawing on questions from the audience.

A brief question and answer period addressed a sole issue regarding the funding of initiatives necessary to address the complex problems posed by invasive species.

Social Science and Resistance to Water Fluoridation

Following opening remarks by Mr. Bill Hirzy with the National Treasury Employees Union, and Ms. Roberta Baskin, a senior reporter for NOW, two speakers addressed the arguments for and against the national policy on the addition of fluoride to drinking water. A question and answer period followed the presentations.

Mr. Bill Hirzy, an officer of the National Treasury Employees Union Chapter 280, provided an introduction to this session noting the original intent for this session to be an information exchange about the science and national policy of water fluoridation, yet the CDC and the United States Public Health Service, with a goal of fluoridation for 100 percent of the water supplies in the United States, declined to publicly defend this national policy. The first involvement of the National Treasury Employees Union in fluoridation was in 1985 as a matter of profession ethics when the recommended maximum contaminant level (MCL) for fluoride was being developed. An employee came to the Union expressing concerns over the standard stating that it did not protect public health against severe dental fluorosis, which many people view as a serious health concern. The Union's most recent involvement has been to sign a statement of concern along with hundreds of other organizations calling for a national review on the policy of water fluoridation.

Ms. Roberta Baskin, a senior reporter for NOW, identified water fluoridation as a controversial issue that needs to be discussed. Her interest in fluoridation peaked in 1997 when the Food and Drug Administration began requiring notices on toothpaste about fluoride as well as warnings about what to do in case of accidental ingestion. This session provided a great opportunity to ask tough questions of the experts.

EPA Drinking Water Regulations for Fluoride

Director of the Health and Ecological Criteria Division in the Office of Science Technology, Dr. Ed Ohanian, presented background information regarding fluoridation and the viewpoints in favor of fluoridation regulations. The current primary drinking water regulations under the SDWA require EPA to set a maximum contaminant level goal (MCLG), an MCL, and a secondary MCL (SMCL). The MCGL is a non-enforceable health goal that allows for an adequate margin of safety, the MCL is the enforceable health standard that is set as close to the MCGL as feasible, and the SMCL is a non-enforceable standard in place to protect against cosmetic and aesthetic effects from drinking water.

In the case of fluoride, the MCL is set at 4 mg/L to protect against skeletal fluorosis, a crippling disease that can result either from a hardening of the bone (osteosclerosis) or a softening of the bone density due to impaired mineralization (osteomalacia); skeletal fluorosis effects include limitation of joint movement, calcification of ligaments, crippling deformities, and muscle wasting.

The SMCL for fluoride is set at 2 mg/L to protect against objectionable dental fluorosis defined as visible dark stains and pitting of teeth; this standard was set based on the incidence of moderate and severe dental fluorosis, with a 0 to 15 percent incidence at this level. Distinct increases in the incidence of moderate dental fluorosis have been documented at levels of 1.9 mg/L and severe dental fluorosis at levels above 2.5 mg/L. Public notification must be sent by utilities if the SMCL standard is exceeded.

Fluoridation is the intentional addition of fluoride to drinking water to reduce the incidence of dental decay and caries. The Unite States Public Health Service has established fluoridation levels of 0.7-1.2 mg/L, which are less than both the MCL and SMCL and are not in violation of EPA drinking water regulations. Of particular note is that the SDWA prohibits EPA from requiring the addition of any substance to drinking water for preventative health care purposes.

In 1997, the status of fluoride changed from a beneficial substance to a nutrient citing that fluoride inhibits the initiation and progression of dental cavities as well as stimulates new bone formation. The Food Nutrition Board of the National Academies of Science developed recommended dietary guidelines for the intake of fluoride based on the age and sex of populations, as follows:

- Infants: 0.1-0.5 mg/day
- Children: 0.7-2 mg/day
- Adolescents: 3 mg/day
- Adults: 3-4 mg/day.

In 1993, EPA requested a review of fluoride regulations by the National Research Council under the National Academies of Science. This review concluded that MCL of 4 mg/L was an appropriate interim standard and recommended re-evaluation of the standard when additional research results became available. EPA responded by publishing its intent to maintain the 4 mg/L MCL level. In 2002, an EPA review of the fluoride regulations examined all drinking water regulations established before 1996 and identified new health effect studies published after

the 1993 review. This prompted EPA to request the National Academies of Science to update their 1993 assessment and recommended an independent review of the data. The EPA charge to National Academies of Science was to review the new health effects and exposure data, evaluate the scientific and technical basis for the MCL and SMCL to identify if they are protective of public health, and identify data gaps for future research. This review will be completed in 2005. More information on this review (project name is Toxicological Risk of Fluoride in Drinking Water and project number is BEST-K-02-02-A) is available at www.nationalacademies.org, and this website also provides the opportunity for feedback on this project.

Fluoridation: An Undefendable Practice

Dr. Paul Connett, a professor at St. Lawrence University, defined fluoridation as the addition of chemicals to drinking water to yield a fluoride ion concentration of 1 mg/L or 1 ppm. While fluoridation began in 1939, the first trials started in the United States and Canada in 1945. None of the chemicals used for fluoridation are pharmaceutical grade.

Fluoride is a naturally occurring element in the sea, in rocks, and in some groundwater samples. Fluoride also occurs in mother's breast milk at 0.01 ppm, which is 100 times less than that added to drinking water systems under fluoridation programs. Thus, a baby's first meals have extremely low levels of fluoride; Nobel prize winner Arvid Carlsson identified this trend and used it as the basis of his charge against fluoridation in Sweden.

Fluoride is an extremely inert chemical, yet its thermodynamic potential lends itself to a very active state that interferes with hydrogen bonds, forms complex ions, and mobilizes the movement of metal ions such as aluminum into places that it normally would not travel. As an example, fluoride accumulates in the human pineal gland, which produces melatonin, and is able to access this gland because it is not protected by the blood-brain barrier. Calcium hydroxy apatite crystals, which form in the pineal gland, were found to have a fluoride level of 9,000 ppm. In animals, fluoride lowers melatonin production by inhibiting enzymes; since there are four enzymes required to produce melatonin, uncertainty remains as to the specific enzyme affected by fluoride.

Opposition exists to a national water fluoridation policy because it is believed to be:

- Unethical by medical standards— fluoridation violates the individual's right to informed consent to medication, does not allow for individual sensitivity to dose, does not control the dose to the individual, and does not allow for the individual response to be monitored. There are many unresolved issues and more research is needed to fill these data gaps.

- Unnecessary— children are already receiving overdoses of fluoride without water fluoridation, and research indicates that 13.5 percent of children already have dental fluorosis on at least two teeth.

- Inequitable— the wealthy can afford to avoid fluoridated water if they so choose. The poor cannot afford bottled water or other avoidance measures, and are forced to receive fluoridated water regardless of their preference. In India, it is well established that fluoridation toxicity effects are the most severe in those with poor nutrition.

- Inefficient— the vast percentage of the added fluoride (~99.97 percent) will be flushed down the drain and toilet, or washed away during car washing and other activities. Fluoridation is only cost-effective because industrial grade fluoride is used rather than pharmaceutical grade.

- Ineffective—a 21 city study determined that there is an inverse relationship between tooth decay and fluoride concentration in drinking water. Using the same data, another researcher (Ziegelbecker) demonstrated that there is no correlation between fluoride and dental disease, and identified a direct relationship between dental fluorosis and fluoride levels. In 1990, Brunelle and Carlos conducted the largest survey ever in the United States (involving 39,000 children and 84 communities) on differences in tooth decay in fluoridated and non-fluoridated communities; the results demonstrated only very small (not significant) differences between fluoridated and non-fluoridated communities in the amount of tooth surface "saved." An Australian study showed even lower findings and a 1998 study by De Liefde concluded that the difference in decay, missing, and filled teeth between fluoridated and non-fluoridated populations is "clinically meaningless." Locker, in 2001 also noted that the magnitude of the effect is not large, not statistically significant, and may not be of clinical significance.

  Boston has been fluoridated since 1978, yet the *Boston Globe* published a front page article indicating a dental crisis in the metropolitan area.

  The CDC listed fluoridation as one of the top 10 public health achievements of the 20th century, meaning that the incidence of decay, missing, and filled teeth for 12 year olds has decreased while the number of individuals drinking fluoridated water has increased. Yet data from the World Health Organization over the same time period, show that other countries, both fluoridated and non-fluoridated, have exhibited a similar trend, thereby refuting the CDC correlation with fluoridated water. CDC did note that the major benefits of fluoride are topical not systemic. Therefore, to this speaker, the addition of fluoride to toothpaste makes more sense than adding it to drinking water.

- Unsafe—as proven by the incidence of dental fluorosis. In the United States, 29.9 percent of the children already have dental fluorosis (mottling of enamel) on at least 2 teeth. Heller et al concluded that the severity of dental fluorosis increases with dose, and the daily dose received by children in unfluoridated areas is already nearing 1 mg/L.

  There also is a superlinear relationship between the incidence of bone fractures in children and the increase in fluoride concentrations; 50 percent of the ingested fluoride is excreted in the urine daily; the remainder accumulates in bone. Wix and Mahamedally (1980) studied the increase of fluoride concentrations in bone over time, but the United States government has not conducted such studies. The pre-clinical symptoms are similar to those of arthritis. Fluoride affects different bones in different ways, and clinical trials found bone hardening in the vertebrates and increased hip breakage, which is a particular concern for the elderly who are most susceptible to this risk. Fluoride also accumulates in the cortical bone, which is cause for concern.

Other studies report negative health effects related to fluoride such as earlier onset of menstruation in young girls (Hilleboe et al.). An Urbansky study stated that silica fluoride would completely dissociate in water, yet this was disproven in German PhDthesis.

Thus, the science still is not there to completely understand all of the effects of fluoridation, such as the effects on hypersensitive populations and an appropriate margin of safety (established by public health policy) to protect more vulnerable populations, which is ultimately what public health policy is supposed to do. Those who promote fluoridation have a formidable task to convince us that the water system is ideal to deliver medication.

Of final note, the use of fluoridation distracts from the real causes of dental decay, which are poverty, poor nutrition, and poor dental hygiene. There is a much greater correlation between tooth decay and poverty than there ever will be in between fluoridation and toot effects. There is a need to conduct independent scientific research on this topic without pressure and intimidation from either the pro- or anti-fluoridation viewpoints.

More information is available at http://fluoridealert.org/reference.htm.

Panel Discussion/Questions and Answers

The speakers had an opportunity to participate in a brief panel discussion drawing on questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) whether EPA policy contents that fluoridation provides safe and effective prevention of dental disease; (2) the potential for the generation of hydrogen fluoride fumes from fluoridated water; (3) the incidence of water fluoridation in Europe and countries that have discontinued the practice; (4) opportunities for public comment on the upcoming National Academies of Science data review; (5) the need for a good exposure assessment as a basis for developing a good risk assessment; and potential health effects of fluoride, especially involving the elderly.

Development of Biological Indices for Coral Ecosystem Assessments

Following opening remarks by Mr. Kennard Potts, with OWOW, four speakers addressed the global and local stressors that human activities, climate change, and El Nino place on coral ecosystems as well as the incorporation of biological indicators for coral in water quality standards. A panel discussion including an audience question and answer period followed the presentations.

Mr. Kennard Potts, with OWOW, introduced the idea of developing indicators for coral reefs in order to provide information on stressors, a 1996 workshop that analyzed methods for assessing reefs, EPA's role and partnerships in coral reef management, and the research EPA is conducting on reefs. Since the early 1990s, EPA has been engaged in coral reef issues with the International Coral Reef Initiative and at a broader level with the Coral Reef Task Force and the Coral Reef Conservation Act of 2000. The goal is to identify low cost and low technology methods to monitor reefs that are simple, inexpensive, and easy to use for "technology transfer" to all coral-bearing nations. In addition, ecosystem management is really people management with the

presentations given in this session providing a framework for developing and applying biocriteria indices.

Assessing the Consequences of Global Change for Coral Reef Ecosystems

Dr. Jordan West, with NCEA, discussed the importance of coral reef systems for tourism, fishing, and biodiversity. Coral bleaching occurs when coral is exposed to an environmental stressor. Coral bleaching disrupts the coral-algal symbiosis resulting in the algae being expelled from the coral host. Coral can recover unless the stressor is continuous and significant. The consequences of coral bleaching include algal overgrowth, disease outbreaks, and a decrease in biodiversity. Local stressors (e.g., pollution, salinity shock, sedimentation, disease) and global stressors (e.g., increasing temperature, light, and CO_2 levels) result in coral bleaching.

There is a linkage between elevated irradiance (light), increasing water surface temperatures, and coral bleaching. Once the mean temperature change of the ocean is exceeded by 1 degree Celsius, bleaching will occur. Both photosynthetic active radiation and ultraviolet radiation can contribute to bleaching. Light penetration into the water is linked to coral bleaching; therefore, greater bleaching occurs in shallow waters, on top of the coral, and in less cloud-protected areas.

Senior Research Scientist with NERL, Dr. Richard Zepp, expanded upon the science linking irradiation and water temperature as well as El Nino effects on coral bleaching. Ultraviolet light induces the formation of a thymine dimer in the DNA of the coral, and this inhibits normal coral functions. This can be measured and used as an indicator of damage.

El Nino, mainly a Pacific Ocean phenomenon, affects many of the other bodies of water. During El Nino years, surface water temperatures increase. The result is a stratification of temperature where the water is hotter at surface with cooler stratifications as depth increases. The clarity of water increases during El Nino; this increases ultraviolet light penetration resulting in increased opportunities for coral bleaching. Research has demonstrated changes in water clarity corresponding with the end of the El Nino event.

Human impacts on coral reefs include changes in seagrass and mangrove areas that contribute to increased sediment and organic detritus. Uncertainties exist as to whether this increases or decreases coral stress. Sediment issues can work both ways to attenuate damage and recovery. The net effect still needs to be understood. In 2002, the Black Water Event in the Florida Bay was a large toxic algal bloom resulting from a large amount of nutrient loading, possibly from the Everglades. This event correlated with significant damage to the coral, but it is still unknown whether or not this may only be a coincidence.

Efforts to address coral issues including the creation of the Coral Reef Task Force under an Executive Order by former President Clinton with a focus on climate change and coral bleaching/disease, land based sources of pollution, over fishing, public awareness, and recreational overuse. The Task Force developed Resolution 5 (October 2002) in partnership with the Department of the Interior, NOAA, and EPA. The first step is to hold a stakeholder workshop in June 2003 on "Corals, Climate, and Coral Bleaching" in Hawaii. This workshop plans to bring together all stakeholders (Federal agencies, non-profits, academia, etc.) for an

informational sharing session to develop a manager's toolkit for rapid response and program development.

Lastly, Dr. West examined a framework for collaborative assessment that recognizes the interconnection of the following:

- Physiochemical patterns—global climate, remote sensing, regional monitoring, and site monitoring
- Coral bleaching—range map, monitoring, biochemistry, and physiology
- Conservation strategies—mitigation, testing strategies, and site assessment and management.

Applying Biocriteria for Coral Reefs in Water Programs

Program Manager for the Biocriteria Program in the Office of Science and Technology, Mr. William Swietlik, discussed the role of biocriteria in the regulatory programs for the waters of the United States. The adoption of biocriteria for all waters and incorporating biocriteria in water quality standards has been a priority in the Office of Water for a number of decades. There has been significant progress and success in developing biocriteria for streams and small rivers, as well as beginning to develop regulatory standards based on these criteria. Once biocriteria are incorporated into water quality standards, they will influence the rest of the processes in the water quality management cycle. The opportunities for application of biocriteria for coral reefs occur in the CWA Sections 305(b), 303(d), 301(h), 403(c), and 303(c).

A water quality standard has the potential to define designated uses, the criteria to protect the uses, and an antidegredation policy for a water body. The designated uses can be either existing uses or restoration goals. Water quality criteria may place limits on a particular pollutant or on a condition of a water body, and the criteria can be designed to protect the designated use. Biological information can be used in water quality standards to develop biological criteria to protect aquatic life uses, describe existing uses, assign appropriate designated uses, refine and subcategorize designated uses, and help make attainment decision. Water quality standards also can address human induced stressors.

Florida, the Virgin Islands, Puerto Rico, and the Hawaiian Islands all have coral reefs and have established water quality standards providing the opportunity to apply biocriteria for coral reefs. The Virgin Islands may provide for the best application of water quality standards using the criteria of the "existing natural conditions shall not be changed."

What do states and tribes need to do to incorporate biocriteria into water quality standards? States and tribes need tested bioindicies, guidance on bioassessment methods and biocriteria development, and program support in order to move forward on incorporating biocriteria into water quality standards. Additional information is available at: www.epa.gov/OST/biocriteria and www.epa.gov/owow/oceans/coral/index.html.

Development of a Coral Reef Index of Biotic Integrity

President of Coral Seas, Inc., Dr. Steven Jameson, discussed the development and use of an IBI for coral reefs as a more accurate way to monitor and assess them, pointing to the success of IBIs in freshwater environments and the transferability of IBIs as indicators to marine environments. Traditional monitoring uses poor reference conditions with constantly shifting baselines and does not provide for early warning capability.

IBIs are a better way to monitor and assess coral reefs, since they allow for the classification of similar environments to support "apples to apples" comparisons. Properly designed IBIs would be sensitive to water quality, habitat structure, flow regime, food, and biotic interactions. Calibrated dose-response metrics capture the most important biological attributes because they assess only the pollutants that are biologically available, assess synergistic and antagonistic pollutant relationships, and reveal biological effects at contaminant levels below the current chemical analytical detection limits. The most important advantage of IBI metrics is that they are useful in detecting degradation by humans that is caused by factors other than chemical contamination, such as temperature, turbidity, salinity, pH, light intensity, and disease. IBIs are sensitive because they assess only pollutants that are biologically available and consider the community assemblage structure, taxonomic composition, individual condition, coral breakage, and biological processes.

Use of an IBI allows for the following:

- Inclusion of different metric types—different metrics can be combined (summed) to obtain a total IBI score, which allows for the ranking of habitats
- Creation of indices for different types of organisms (e.g., focus areas)
- Detection of cumulative impacts through the use of fixed reference (baseline) conditions to remove the effect(s) of shifting baseline condition
- Early warning capability determined based on a dose-response curve.

IBIs have a diagnostic capability, which uses specific response metrics and metrics sensitive to mixtures of pollutants to monitor and assess coral reef health. IBIs can also use data to identify what is causing the changes, which in turn supports trend and problem identification. IBIs also can be used to certify marine protected areas or to identify whether progress in remediation is being made.

Building upon previous IBI experience with freshwater, the addition of more IBIs may not produce greater resolution. IBIs only require one sampling method within the same physical environment (coral reef zone) thereby minimizing the sampling effort, data volume, environmental impacts, and cost.

There is a need to establish a classification system for monitoring and assessment of coral reefs, establish marine ecoregions, standard classification terminology, test metrics for dose response capabilities, and reference conditions for viable metrics. From these efforts, IBIs can be created

and calibrated for specific conditions. These IBIs will in turn support the development of biocriteria. Determining what is acceptable for coral reef biotic integrity will be challenging scientifically because of the current limitations in our understanding of the natural system and how far the system can be stressed while still sustaining the ecology. In addition, incorporating effective biocriteria into regulation will be politically challenging because of their significant economic impacts.

Coral reefs are threatened globally by CO_2 and sea surface temperature changes, therefore it is important to reduce other stressors and increase survivorship. Local success in preserving coral reefs requires actions at the local and global levels. Time is running out quickly for coral reefs and progress must continue to be made through local, national, and international partnerships. This will require strong national leadership and a sustained commitment to forge and maintain these partnerships. Establishing a new paradigm for coral reef monitoring assessment, using IBIs and biocriteria, will provide critically needed early warning and diagnostic tools to help reduce the impacts of controllable local stressors.

Panel Discussion/Questions and Answers

The speakers had an opportunity to participate in a brief panel discussion drawing on questions from the audience.

A brief question and answer period following each presentation addressed a range of topics. These included: (1) nutrient sources for the Black Water Event and whether color can be used as an indicator of nutrient movement; (2) interagency programs to address nutrients in the Everglades restoration; (3) whether elevated CO_2 as a stressor of coral reef health is a direct or indirect effect; (4) how to calibrate dose-response metrics for a coral reef; and (5) concerns about releases of asbestos and PCBs from World War II ships and their potential impacts on coral reefs.

The Impacts of Urban Drainage Design on Aquatic Ecosystems in the United States

Following opening remarks by Mr. Jamal Kadri, with the Office of Water, two speakers addressed the use of Smart Growth principles in urban areas and tools supporting Smart Growth initiatives. A panel discussion including an audience question and answer period followed the presentations.

Mr. Jamal Kadri, with the Office of Water, initiated the discussions by describing EPA's role and interest in urban drainage design. Mr. Kadri then introduced the session speakers.

OWOW and Smart Growth: Integration of Water Programs through Smart Growth Principles

Ms. Diane Regas, with OWOW, discussed Smart Growth principles as another approach to watershed protection and management, and how these principles can be used to protect water resources such as estuaries, which are extremely important ecologically and economically. Estuaries generate $110 billion per year in revenue and help to maintain biodiversity.

Approximately 44 percent of estuaries are impaired, and estuary impairment is growing as population increases.

The number of vehicle miles traveled and the rate of land development are increasing much faster than population growth, and these changes correlate with increases in pollution seen in water. A study showed that approximately 32 percent of the nitrogen loading to the Chesapeake Bay is attributable to air deposition. Approximately 53 percent of the population in the United States lives on the coasts. In addition, almost 10 percent of watersheds had 15 percent or more of total watershed land is developed, particularly in the East Coast and Great Lakes areas. When effective imperviousness exceeds 10 percent of a watershed's total acreage, large hydrological changes in the watersheds and a huge decline in biodiversity are seen. Intuitively, some would then argue to maintain watershed imperviousness at a level below 10 percent.

Annual vehicle miles traveled per household decreases by 35 percent when residential density increases from 2 units per acre to 10 units per acre. Since residents are closer to work, stores, and neighbors, the number of miles traveled is reduced as population density increases. Yet growth affects habitat integrity and quality, and land development can disrupt wetlands. For every acre of redeveloped brownfields, it is estimated that 5 acres of greenfields are saved. Watershed protection requires being concerned with a suite of goals that need to include economic and biodiversity goals not just water quality goals.

EPA has worked closely with local officials since watershed planning is an important tool to help local officials make informed decisions. As an example the Office of Water recently developed a Phase II storm water management guide. Yet, EPA cannot protect water resources alone. EPA has and must continue to foster partnerships with local governments to protect drinking water resources. EPA is focused on investing in these partnerships and shifting funding to non-point source projects and smart growth projects to protect drinking water and other water resources. EPA has worked with the National Association of Counties on non-point source issues to help municipal officials identify how their decisions will affect the water quality surrounding them.

Two Tools for Smart Growth

Executive Director for the Center for Water Protection, Ms. Hye Yeong Kwan, discussed two tools for Smart Growth:

- Impervious cover as an indicator for watershed quality

- Use of local roundtables to introduce smart growth concepts to community leaders seeking to protect their watersheds.

Impervious cover is defined as land uses that do not permit rainwater runoff such as parking lots, streets, and buildings. A model of impervious cover can be used to develop a scale for stream degradation based on the percentage of impervious cover in the watershed. At 10 percent impervious cover, impacts on the stream are visible and the stream is classified as sensitive. At 30 percent impervious cover, streams are labeled as impaired or non-supporting. Using an example of a Piedmont stream, at 5 percent impervious cover, the stream appears healthy and exhibits great diversity and quantity of biota. At 8 percent, the stream still has sinuosity, good

riparian cover, and still appears relatively healthy, but sediment deposition is beginning to occur. At 20 percent, there is increased sediment deposition and bank degradation that exposed a sewer pipe. At 30 percent, tree roots are visible on the stream banks. At greater that 65 percent impervious cover, this stream may still be labeled a "riparian corridor," but not in appearance.

The Center for Water Protection has conducted over 225 studies on the relationships between impervious cover and aquatic quality relationships. These studies identified other indicators of watershed quality, including:

- Forest cover – leading candidate, has the opposite effect of impervious cover
- Cultivated land – parallels impervious cover
- Riparian forest community
- Turf over in impacted watersheds (10 to 25 percent impervious cover).

The first three indicators are critical for sensitive streams (0 to 10 percent impervious cover).

Studies on the relationship between impervious cover and hydrology showed a high correlation for annual runoff, peak discharge, and channel backflow frequency. In addition, as urbanization increases, riparian buffer width decreases, and the floodplain increases with increases in the impervious cover, which in turn results in channel enlargement increases. Furthermore, large woody debris decreases as impervious cover increases and is a very good indicator of stream quality.

In the study entitled "Effect of Urbanization on the Natural Drainage network in the Four Mile Run Watershed," the Center for Water Protection examined the relationships between impervious cover and biological indicators in that region. Such studies show a strong positive relationship between an increase in impervious cover and an increase in bacteria, nutrient, sediment, and pesticide levels. Other findings include:

- Fecal *coliform* levels in urban storm water average about 200; maintaining low *coliform* levels is extremely important to maintaining fishable and swimmable waters

- As impervious cover increases, insects, fish diversity, and other biotic indicators decrease and biological integrity also decreases

- Impervious cover impacts natural biota (sensitive species) negatively.

For sensitive streams, pre-development hydrology is a reasonable goal, but there may be other concerns, such as swimmability or contact issues in more urban areas. Impervious cover is not an exact measure but "a critical point" and should always be viewed as such. For example, planning in the Goose Creek watershed used impervious cover to assess overall watershed quality even before work commenced. The assessment found that barely any subwatersheds had less than 10 percent impervious cover, 35 of 42 subwatersheds fell into the 10 percent or sensitive category, and two subwatersheds fell into the impacted (greater than 25 percent impervious cover) category. Using the "rural water quality impacted" criteria, almost half of the watersheds are classified as impacted.

Since development happens locally, a local roundtable approach seeks to change local codes and ordinances to align with smart growth objectives using a consensus building process. This involves six steps:

1. Selecting a community—requires a political and local jurisdiction that is willing to change, has a current growth rate that is significant, and has growth management and costs that are current and pressing issues. To date, about a dozen communities have participated in this project.

2. Doing the background research—this is important to understand the basic tenets of Smart Growth, to become familiar with local codes and ordinances, and to identify and contact potential stakeholders by thinking beyond those that comprise the planning commission, such as developers and environmental persons.

3. Introducing the stakeholders to the process—hold meetings to get to know the community leaders, introduce smart growth, develop a roundtable, review consensus-building process, and divide into subcommittees by issue.

4. Facilitating consensus—this requires the organizer to be an active partner in facilitating a consensus handholding and personal phone calls. Advocates for change must satisfy community concerns and this requires keeping an open mind (i.e., avoid being set on certain expectations).

5. Holding a final roundtable meeting—to provide closure to the process.

6. Conducting "after" care—follow-up is essential so that people understand what went into this consensus building process.

Online resources with more information on this roundtable process are available at: www.cwp.org and www.stormwatercenter.net.

Panel Discussion/Questions and Answers

The speakers had an opportunity to participate in a brief panel discussion drawing on questions from the audience.

A brief question and answer period following each presentation addressed a range of topics. These included: (1) consideration of other indicators in Smart Growth, such as lifestyle, number of vehicles per household, and gas efficiency that link to environmental impacts; (2) challenges in consensus building with stakeholders that believe nothing is wrong in the community and the need to make an economic link to smart growth as well as to break barriers through consensus building; (3) how to balance scale in watershed protection by setting reasonable restoration goals for impervious cover; (4) consideration of efforts necessary to restore developed watersheds to achieve a desired impervious cover goals; (5) the limited benefits of impervious cover data and research for urban areas pointing to the need for multiple tools such as impervious cover percentage for an entire watershed; and (6) the challenges in providing technical assistance to all the communities that wish to undertake Smart Growth principles.

Innovative Monitoring Techniques

Following opening remarks by Ms. Susan Holdsworth, with OWOW, three speakers addressed innovative monitoring techniques being developed to better understand which waters are impaired or are in danger of impairment. A panel discussion including an audience question and answer period followed the presentations.

Ms. Susan Holdsworth, with OWOW, noted the need for additional water quality monitoring and data to fill holes and gaps in our current knowledge about which waters are impaired or in danger of impairment. Only a fraction of the waters in the United States have been monitored, mostly on streams and rivers, and this raises questions about our efficiency in resource utilization to address water quality across the United States. EPA resources have been devoted to providing guidance for state monitoring programs, training, technical assistance, developing, testing, and refining of methods. Ms. Holdsworth then introduced the three speakers in this session.

30 Years of Progress Through Partnerships: Biological Indicators

Ms. Susan Jackson, an Environmental Scientist with the Biocriteria Program, discussed the use of biological indicators as a means for assessing water quality and demonstrated the added value of their use. Biological indicators are any organism, species, assemblage, or community characteristic of a particular habitat or indicative of a particular set of environmental conditions, such as the presence or absence of a species. Human activities are major drivers in the alteration of water resource features and affecting the biological endpoint and responses.

An example illustrating the added value of biological indicators involves a 12-year effort in Ohio. Bioassessment is the evaluation of the biological condition of a water body using biological surveys of the structure and function or the community of resident biota. Research comparing the results of chemical and biological assessments noted that:

- 58 percent of the time, the findings of the chemical assessment and bioassessment agree that a problem exists
- 36 percent of the time, the chemical evaluation indicates no impairment when a biological survey does indicate an impairment
- 6 percent of the time, the bioassessment indicates no impairment while the chemical assessment does, representing a disagreement in findings when agreement was expected.

Thus, this variable can act as a good internal quality check.

When selecting the community components (such as target species and taxa) for metrics, a key question is whether tribes and states can implement the tools. Also important is the need to develop more than one metric, such as fish, algae, etc. Good wetland indicators include fish, birds, and plants.

Bioassessments are still required on larger rivers. The current focus is on intermittent streams, and this is being conducted by working on a waterbody-by-waterbody basis across the states. Stream bioassessment is conducted either by collecting fish through electric shock or using insects as indicator organisms in a benthic macroinvertebrate community bioassessment. Other methods include collection and analysis of artificial substrates colonized by insect larvae; identifying sensitive organisms in streams such as caddisflies, dragonflies, and magflies; identifying tolerant organisms in streams such as leaches, midges, snails, and scuds; and examining the metric behavior along the stressor gradient.

Biological information will help answer tough management questions at the global, Federal, state, and local levels including:

- What is the condition of the resource?
- Is there a problem?
- What do we tackle first?
- What do we want to maintain or restore?
- How do we know when we get there?

Under the CWA, states have the primary responsibility to manage their water. Therefore, different methods, indicators, and management practices increase the difficulty in sharing and communicating data, but do allow for analysis of creative best management practices. However, information sharing across state, tribal, and political boundaries is important. In addition, critical questions for such monitoring programs include how to acquire comparable data, how to aggregate data, and how to communicate the data to the public. Solutions to these challenges include the development of performance-based monitoring programs.

An example illustrates the use of an aquatic life conceptual model to identify a Biological Condition Gradient. The purpose of the Biological Condition Gradient exercise is to protect high quality waters, produce scientifically defensible benchmarks, and create a common framework for working with the public. This involved "blind" data exercises to "pick the brains" of scientists in different regions to determine how they establish the reference condition and if there are common decisionmaking patterns, terminologies, and scientific principles regardless of method. Key findings were that the scientists rapidly built a consensus and used common scientific principles. The draft aquatic life conceptual model includes six levels of ecological change: Natural Structure and Function, Minimal Change, Evident Change, Moderate Change, Major, and Severe.

EPA continues to work with diverse partners to promote the more frequent use of biological indicators and to move the science forward. These partners include state and tribal scientists and the scientific community (academic, agency, private), as well as internal EPA collaboration.

Innovative Monitoring: Probabilistic Monitoring Approaches

Mr. Barry Burgan, a Senior Marine Scientist in OWOW, discussed probabilistic monitoring approaches as a cost-effective, innovative technique to assess wetlands and estuaries. This approach incorporates randomized site generation and allows for a description of the whole by sampling the parts, thus lending applicability to national assessments. Probabilistic monitoring is

not a substitute for compliance monitoring because it does not identify all impaired assessment units. Instead, probabilistic monitoring is best suited for targeted, site-specific monitoring. This type of monitoring design enables evaluation of national, wide-spread issues in a cost-effective manner, generate scientifically defensible comprehensive assessments of water resources at all scales and at less cost, and provide core surface water, estuarine, and wetland indicators for comparable results.

Many states use probabilistic design approaches and are still evaluating the data. Indiana is the first state to have reported using probabilistic designs. A national costal condition report divided the country into different regions, examined each region separately, and aggregated the data for consolidated reporting. Two additional examples include a multi-year design study in Casco Bay, Maine, under the National Estuary Program and an Indiana fish community probabilistic assessment, which used IBIs to calculate a total score that related to the condition of the fish and the quality of the watershed.

Benefits of probabilistic monitoring includes a cost-effective approach to establish the baseline and trends for national/regional/state water quality, the ability to assess human health and ecological program effectiveness at all scales, and the ability to support the equitable allocation of the CWA 106 resources among states.

Incorporating habitat differences into a probabilistic design model depends upon the scale of the study. For a state-level model, habitat differences are less important as a result of to the larger scale. At the river or stream level, identifying the specific habitat of interest and targeting those habitats is more important given the smaller scale of the analysis.

The Next Generation of Wetlands Assessment – The Upper Juniata Watershed

Assistant Director of the Penn State Cooperative Wetlands Center, Ms. Denise Wardrup, discussed the use of GIS, land use, and landscape information to assess watershed condition assessment prior to an onsite survey, and drew on the Upper Juniata Watershed as an illustrative example of this approach. Wetland assessment on a watershed basis is important because watersheds are a more efficient unit from a financial, social, and ecological perspective. In addition, the watershed level is conceptually attractive for local managers because it occurs at a scale that people can manage.

Not all decisions call for the same level of information. Therefore a multi-level assessment methodology is needed that targets:

- Inventory—how do we find the wetlands?
- Condition—how do assess their ecological integrity?
- Restoration—how do we use the information to improve conditions?

The Upper Juniata is a large tributary to the Susquehanna River, which is the largest tributary to the Chesapeake Bay. The objective of assessing the conditions of the wetlands in the Upper Juniata Watershed proved difficult because most of the wetlands were on private property. Because intern and volunteer teams were used to assess the watershed, there was some concern that EPAs quality control requirements for the data might not be met; however, the data did meet

those requirements demonstrating that this may be a cost-effective approach for monitoring and assessing wetlands. The reference standard is forested area; agriculture use is the major conversion activity in the region and occurs at varying degrees.

Analyses of land conversion from forested to urban and agricultural land was conducted using GIS software to analyze land use patterns such as percent forested area, mean forest patch size, the diversity index, and road density. In the Upper Juniata Watershed, land use began as forested, but is moving toward agricultural. Using an approach of correlating percentage of forested area with ecological condition, 83 wetlands in the watershed were classified at the desktop.

A rapid assessment was also conducted. This requires the use of site-specific stressors for the four main types of wetlands, as they differ by water source. Also necessary for rapid assessment is a landscape profile, which, for the Upper Juniata wetlands, showed headwater complex as the most important and most frequent class. Also required is a site visit to identify stressors, such as dissolved oxygen levels, hydrological modification, sedimentation, contaminant toxicity, turbidity, and eutrophication among others, that cannot be identified from aerial photography. Analysis of these stressors when coupled with landscape information provides the following results:

- At greater than 85 percent forested area, the only stressor evident is hydrologic modification at approximately 33 percent of the sites

- At 50 percent forested, there are a large number of stressors and more than 60 percent of the sites have hydrological modification.

Are stressors associated with land cover characteristics? At the reference site, 42 percent of the headwater floodplains were affected by sedimentation. Certain human activities give rise to stressors and those have important impacts on the systems.

When comparing landscape and rapid assessments, rapid assessment provides more information because it draws on site-specific information. For landscape assessments, close to 70 percent of the information can be explained if the wetland type is specified; however, for rapid assessments, the amount of information that can be explained increases significantly. In addition, rapid assessment is meant to be more predictive not more prescriptive.

Panel Discussion/Questions and Answers

The speakers had an opportunity to participate in a brief panel discussion drawing on questions from the audience.

A brief question and answer period following each presentation addressed a range of topics. These included: (1) use of large-scale, random sampling to site-specific identification of stressors; (2) incorporation of habitat differences in estuary evaluations; (3) different methods for land use conversions; and (4) consideration of systematic bias in data reporting for landscape and rapid assessments.

Volunteer Monitoring—Ten Years of Progress

Following opening remarks by Mr. Joe Hall, with OWOW, four speakers addressed the use of volunteer monitoring in general and in specific support to wetlands, coastal, and estuarine programs.

Mr. Joe Hall, an Environmental Scientist in OWOW, introduced this session and the speakers.

Volunteer Monitoring: 10 Years of Progress, What's the Future?

Ms. Alice Mayio, Environmental Protection Specialist in OWOW, provided an overview of volunteer monitoring in the past and present, EPA sponsorship of volunteer monitoring, partnerships, and the applicability of voluntary data. People become volunteers because of their genuine concern about local water, their desire to know more about the surrounding environment, and their desire to share whatever special localized knowledge they may have to offer. The largest group of volunteers involves mid-life adults (40 percent) followed by youth under 18 (28 percent) and seniors (25 percent). Currently, there are 830 volunteer programs nationwide to monitor rivers, streams, lakes, reservoirs, estuaries, and wetlands, and these programs collect "professional" data on physical conditions for habitat assessment.

EPA sponsors volunteer monitoring programs to support education, promote environmental stewardship, promote involvement, support decisionmaking, and gather data. Some volunteers may have collected data on streams and rivers for up to 25 years. Currently, only 19 percent of all stream miles have been assessed; therefore, this information from volunteer programs is quite valuable. EPA provides technical support, workshops for information exchange, and limited funding under the National Estuary Program and non-point source funding programs. Universities and other educational institutions, independent organizations, and environmental organizations such as the Sierra Club all sponsor volunteer monitoring as well.

Volunteer monitoring data is currently used for local action. "Persistent eyes and ears" can report invasive species first as well as loss of macroinvertebrates leading to local decisionmaking. Volunteers also support education and outreach at local fairs, provide local articles in the newspaper, or make presentations to children's classrooms. At the state level, the data collected by volunteers supplement limited state data for reporting under CWA Sections 305(b) and 303(d) and serve as a screen for problem identification. The credibility of volunteer data depends on (1) the use of an approved Quality Assurance Project Plan, (2) receiving training in quality assurance in the field and the laboratory, (3) cooperation with data users, (4) strong leadership, and (5) the involvement of scientists and professionals.

Two models were discussed as illustrating the volunteer approach: a "community workers" model, and a "science by the people model." Under the "community workers" model, a sponsoring agency determines the course of the project and uses the volunteers as labor. For example, the Maryland DNR recruits and trains volunteers to use specific protocols at designated sites, and the DNR conducts the analysis of the collected data. Under the "science by the people" model, volunteers conduct the majority of problem identification and determine how to collect, analyze, and use the data. An example program is the Alliance for Aquatic Resource Monitoring under which individuals identify a topic for a study, scientist(s) assist in the setup of

the research model and training, and the volunteers ultimately collect, analyze, and use the data in the way they want. The advantages of these approaches include citizen empowerment and involvement as well as maintaining the interest of the volunteers. The disadvantages include the need for the service provider to continuously come up with new programs, which is time consuming.

A few success stories of partnership results include the Virginia Save Our Streams initiative that developed a revised macroinvertebrate method and the Florida Lake Watch that analyzed reliability protocols and produced 24 peer-reviewed articles.

Wetland - Volunteer Monitoring: Ten Years of Progress

Ms. Kathleen Kutschenreuter, with OWOW, discussed how volunteer monitoring relates to wetlands protection and data collection. Wetland ecosystems provide an amazing diversity yet over half of the wetlands in the United States have been drained or converted. Wetlands are a vital link and are highly productive with unique hydrology and soils. Wetlands provide many key functions such as flood reduction and recreation yet they tend to be overlooked when surface water is in discussion. National Wetland Goals established under the CWA include no overall loss of wetland acreage and to provide for an annual net increase of 100,000 acres annually by 2005.

Volunteer program support such as technical and financial assistance is provided under the National Wetland Monitoring Strategy. While EPA could simply support volunteer monitoring for the education and outreach benefits, EPA instead takes volunteer monitoring one step further by using volunteers to help meet the objectives of the CWA. For example, a recently established National Wetland Monitoring Working Group includes members from a majority of the states as well as 5 tribes. EPA is looking for ways to include volunteers in this Working Group.

Grants under 104(b)3 are the biggest financial tool in developing wetland tools to assist state and local tribes and involve an investment of about $15 million per year. Through these grants EPA is seeking to increase the protection of vulnerable waters, adopt an ambient wetland monitoring and assessment program nationwide, and improve successful mitigation of impacts on wetlands.

Cooperative projects and partnerships need to focus on transferable processes and products to enable information exchange between regions on best practices. Examples of successful cooperative EPA projects and partnerships include the Isaac Walton League (wetlands conservation and sustainability), the Massachusetts Bay Volunteer monitoring and Health Assessment Group (Handbook for Monitoring New England Salt Marshes, potentially applicable regionally or nationally), and the Earthforce Wetlands Project (state, tribal, and local coordination case studies and trends to identify volunteer programs, quality assurance in volunteer programs, and how states can use these data to fulfill their CWA obligations). These examples demonstrate the usefulness of volunteer monitoring.

Volunteer groups are unique and vary in funding, background quality assurance, and other areas. As a result, *Volunteer Wetland Monitoring: An Introduction and Resource Guide* was developed to maximize the benefits achieved by the volunteers and the states from volunteer monitoring programs.

May is American Wetlands month and more wetland information is available from the EPA Wetland Hotline at 1-800-832-7828.

Volunteer Monitoring: A Coastal Perspective

Mr. Joe Hall, with OWOW, explained how volunteer monitoring supports coastal and estuarine monitoring initiatives. The National Estuary Programs use volunteer monitoring to collect data on the condition of the Nation's estuaries. There are 28 National Estuary Programs that address estuaries designated as areas of national significance. These areas are continuously monitored and evaluated. In addition, EPA developed the *Volunteer Estuary Monitoring Methods Manual*, which provides for the standardization of methods and pooling of resources for increased buying power. EPA also provides technical support and coordination to volunteer groups.

Volunteer estuary monitoring workshops and a newsletter are two ways of sharing information between volunteer groups. Two-thirds of the participants in the workshop are the volunteer monitoring leaders themselves. Government organizations at all levels (state, local, Federal) and non-governmental organizations also participate at these workshops. Examples of special topics addressed at these workshops include:

- GIS
- Dealing with Hydrilla
- Observing field conditions
- Nutrients and pesticides
- International collaborations (Canada and Mexico) to look at border problems of pollution
- Equipment management
- Land use at Charlotte harbor.

More information on volunteer monitoring resource ideas and other topics is available at: www.epa.gov/owow/oceans and http://www.epa.gov/owow/estuaries/monitor/.

What's In the Future?

Ms. Alice Mayio, with OWOW, discussed future challenges and opportunities for volunteer monitoring programs. Challenges include funding, improved quality assurance of data, data management, and broader use of volunteer data. Future opportunities include invasive species monitoring, creating regional networks to cost-effectively pool data, adding volunteer monitoring data to STORET (through facilitation of data entry), and participation on monitoring councils.

Section VI: Emerging Technologies

Tuesday and Wednesday, May 6-7, 2003

The purpose of this breakout session on the second and third days of the meeting was to focus on the application, use, and research directions for diverse emerging technologies, including computational toxicology; advanced information technology, simulation, and modeling; biotechnology; and nanotechnology. Each session included a panel discussion and opportunities to respond to audience questions that provided additional information and insight on a variety of emerging technology topics.

Dr. William Farland, Acting Assistant Administrator for Science and Research and Development for ORD, led a session addressing the application of computational toxicology to solve environmental problems. Presentations included a toxicogenomic predictive model of chemical effects, highlights of EPA's research activities involving computational toxicology and its applications for risk assessment, quantitative structure-activity relationship models and other computational tools supporting evaluation of chemical effects on human health, applications of computational toxicology and genomics to drinking water research, research initiatives using genomics to assess risk to ecological sustainability from environmental stressors, historical and future uses of structure-activity tools to assess pesticides and toxic substances, and highlights of the recently established NIEHS National Center for Toxicogenomics.

Dr. Gary Foley, with NERL, led a session addressing innovations to advance the detection of threats and to optimize environmental decisionmaking. Presentations included an overview of the Federal Networking Information Technology Research and Development Program, diverse information technology initiatives within EPA for enhanced data acquisition and analysis, use of satellite-based remote sensing systems to evaluate human and ecosystem health issues, an aircraft-based surveillance system to support first responders to chemical spills and other emergencies, use of computer imaging and wind tunnel testing to characterize the temporal and spatial patterns of contaminant movement and deposition from the collapse of the WTC, and the use of real-time monitoring data to communicate air quality conditions to the public.

Dr. Hugh McKinnon, Director of the National Risk Management Research Laboratory (NRMRL), led a session addressing developments and applications of biotechnology. Presentations included the use and implications of molecular farming to replace traditional chemical manufacturing, highlights of the EPA biotechnology research program, the role of science in the regulation of bioengineered crops, monitoring strategies to assess the risks associated with bioengineered crops, use of satellite-based remote sensing systems to support compliance monitoring for bioengineered crops, the production and use of biopolymers to create biodegradable plastics and other products, and highlights of the USDA Biotechnology Risk Assessment Research Grants Program.

Dr. Jack Puzak, Acting Director of NCEA, led a session addressing developments in understanding nanotechnology and its applications. Presentations included the use of nanotechnology to enhance filtration membrane performance, highlights of the National Nanotechnology Initiative, the production and use of polysiloles as chemical sensors for arsenic and hexavalent chromium, the production and action of biopolymers to remove heavy metals from wastewater, understanding the molecular dynamics of colloidal nanoparticles, and the development and use of nanocrystalline zeolites as catalysts.

Applying Computational Toxicology to Solving Environmental Problems

Following opening remarks by Dr. William Farland, Acting Assistant Administrator for Science and Research and Development for ORD, seven speakers addressed the concepts, tools, and applications of computational toxicology for understanding the human health and environmental effects of chemicals. A panel discussion including an audience question and answer period followed the presentations.

Computational Toxicology: Bolstering the EPA's Mission

Acting Assistant Administrator for Science and Research and Development for ORD, Dr. William Farland, welcomed attendees, thanked Dr. Elaine Francis for organizing the speakers for this session, and provided an overview of this half-day session on computational toxicology. The general topic, computational toxicology, is defined as an emerging science that begins to integrate genomics, quantitative-structure activity relationships (QSARs), informatics, and systems biology, including pharmacodynamics useful to understanding the mode of action and screening chemicals in virtual system (*in silico*), thus moving away from *in vivo* and *in vitro* types of studies.

This emerging science brings together diverse disciplines through systems biology and computation methods, which is anticipated to lead to more streamlined testing programs for all chemicals that the EPA is charged to evaluate. At present, there is heavy reliance on animal testing to understand potential impacts to humans. Computational toxicology will enable the achievement of similar understanding through a systems approach to the biology and risk, with the associated advantages that include reduction in use of animals for such testing purposes.

Toxicogenomic Predictive Modeling

Vice President for Toxicogenomics at Gene Logic, Inc., Dr. Donna Mendrick, discussed current activities to build a toxicogenomic database, use of customer-generated data, and prediction of pharmaceutical and chemical effects using the database and related toxicogenomic tools. While classic *in vivo* toxicity studies monitor about 100 parameters, toxicogenomics allows monitoring of the entire genome. This in turn enables prediction of toxicity before or in the absence of classical signs, and provides clues as to the mechanisms of toxicity such as the genes, metabolic pathway, or biological pathway involved.

The ToxExpress® Working Group is developing a toxicogenomic database that will serve as a tool to improve chemical safety through predictive modeling. The development of this database involves many firms and requires integration of expertise from bioinformatics, database management/software, biostatistics, molecular biology, pharmacology, toxicology, and microarrays among others. Efforts to date have looked at more than 130,000 microarrays. To build a robust database, vehicle, multiple doses, and time points are included in each study to enable evaluation of time effects and to address differences in animal feed that result in a drift in results. Since each run generates 26,000 data points, this database becomes quite large.

Uses of toxicogenomics identified by their customers include *in vitro* screening to rank compounds and determine which show the least toxicity; short-term *in vivo* experiments; and mechanistic analysis of toxicity to understand the underlying mechanisms and to look for clues in the genes to help refine further research and to determine whether the impacts are animal-specific and therefore not relevant to humans.

The methodology examines the impacts on each gene in the normal population. This involves graphing the frequency versus the average difference value, then comparing this information to each gene's result when exposed to a toxicant. Each gene receives a different weighting (linear discriminant analysis) depending upon its response to the toxicant. Note that there is often much overlap between normal and exposed genes.

Gene Logic uses multiple methods to assess data compatibility. A large reference database such as this one allows the selection of genes that exhibit the lowest variability due to biological and processing differences. This facilitates comparison of data from different sites. In addition, predictive model validation is also conducted involving extensive statistical cross-validation. Models are also tested using customer-generated data provided to Gene Logic, in a blind fashion. The data are sent to Gene Logic to assess gene compatibility, run the predictive models, then issue a report of whether the compound appears toxic or not. To date, Gene Logic has correctly identified 90 percent of the true hepatotoxins with a zero percent false positive rate. Gene Logic subsequently determined that the data came from five different rat strains so the majority of the compounds tested (22 of 32) were not already in the predictive models, thus resulting in a true test of the database as a predictive tool.

Dr. Mendrick provided examples of the application of the database and associated predictive modeling involving diethylnitrosamine and ciprofibrate. These examples illustrated that toxicogenomic predictive modeling can be applied 24 hours after dosage, thus saving time and money, and can correctly identify both short- and long-term hepatotoxicity. This technique also enables mechanisms of toxicity to be evaluated in conjunction with the pathology and compound-match information as well as analysis of individual genes.

Dr. Mendrick also provided examples of predictive modeling for three acetylcholinesterase inhibitors that are not toxic to animals but are toxic to humans. The toxicogenomic predictive models showed results comparable to human clinical findings that classical clinical chemistry did not detect. The key is to know what genes to look at. In this study, over 200 genes were dysregulated by the compounds being tested, but many were not hepatotoxicity markers. Therefore, a change in a gene does not necessarily signify a toxic event.

This combination of animal testing, a large database of genes, and toxicogenomic predictive modeling enables accurate toxicity predictions for compounds not already studied. While in a minority of cases data compatibility issues have arisen, methods have been successfully developed and implemented to enable the use of such data. In addition, building a large database of genes helps to identify normal expressing ranges of genes that are not involved with toxicity, supports statistical confidence in determining statistically significant events since many toxicity-relevant genes exhibit small changes in gene expression, and enables the construction and reliable use of robust toxicogenomic models. Because the database design incorporated

variability information, broader applicability was achieved such as the prediction of results in different rat strains.

One question raised during the presentation involved model sensitivity to a chemical that has more than one mode of action or responses to chemical mixtures. Where a chemical has multiple effects, the more prominent effect may mask more subtle effects that may be of interest. A second question concerned the false positive rate encountered in this approach. The model can be adjusted to sensitivity including the need to reduce false negatives, which in turn would increase the number of false positives. The database includes a number of negative controls, in particular the elimination of genes that are responding but are not toxicity-relevant.

EPA's Research Program on Computational Toxicology

Director of NHEERL, Dr. Lawrence Reiter, provided an overview of the health toxicity program at EPA, challenges facing the Agency, and the use of a conceptual or science framework for guiding research. To carry out its mission, EPA relies on quantitative risk assessment and uses that information to inform decisionmaking. There is a whole risk continuum beginning with source/stressor formation that proceeds to exposure then to effect/outcome. This is typically applied in research to one chemical at a time. The EPA programs have many lists of priority chemicals including endocrine disrupting chemicals (EDCs), pesticide inerts, high production volume chemicals, and Contaminant Candidate List chemicals, with no risk-based criteria for setting testing priorities, yet EPA cannot possibly test all of these for every possible endpoint. In addition, there are multiple regulatory authorities for testing and each has different testing requirements with few options for flexible testing approaches. There is currently a lack of data necessary to reduce uncertainties that exist in comprehensive risk assessment such as extrapolation of toxicity data across species.

Better tools are needed to understand the risk continuum and genomics shows much promise for application in this area. Computational methods and bioinformatics may help to identify what endpoints to measure and the quantitative models may help to address the challenge of evaluating large numbers of chemicals. The overall goal is to integrate modern computing and information technology with molecular biology and chemistry to improve EPA's ability to prioritize data requirements and risk assessments for toxic chemicals. Overall program objectives are to improve linkages in the source-to-outcome risk paradigm, improve predictive models for screening and testing, and enhance quantitative risk assessment.

Better characterization of toxicity pathways supports better understanding of the exposure-to-adverse-outcome portion of the risk continuum paradigm. Exposure to a xenobiotic chemical results in altered organ function and adverse outcome. *In vivo* approaches help in understanding these relationships at the molecular/subcellular, cell, organ/tissue, and individual organism levels, which can be linked to an outcome that is relevant to EPA and to risk assessment. *In vitro* methods can be used to understand cellular processes and to improve predictive models. Then, *in silico* methods can be used to understand and/or predict the molecular/subcellular effects. An example is current research into the potential use of diagnostic molecular indicators and whether gene expression pathways can serve as indicators for a specific stressor or family of stressors. With 193 genes detectable in both blood and uterus, only 18 of these genes are significantly

altered when exposed to estradiol; if these changes can be shown to occur in a dose-related fashion, models can then be developed.

Use of QSAR approaches help to improve predictive models for screening and testing, including pollutant-driven and chemical-driven approaches. Estrogen receptor binding was offered as an example of how to address the need to test 6,000+ chemicals by using predictive modeling to identify the highest priority chemicals for testing, the lowest priority chemicals for testing, and chemicals that may not require any testing. Another example involved the use of QSAR to predict the relative potency of haloacetic acids and the concentrations necessary to produce developmental malformations; experimental results tracked well with QSAR prediction and efforts are now being extended to the pathway of effect – looking at changes in tissue level, gene activation patterns, and proteonomic approaches to evaluate protein phosphorylation, believed to be the key mechanism leading to the birth defects. The overall desire is to expand the QSAR approach to a wider range of chemicals.

Cross-species extrapolation continues to be a major area of uncertainty when conducting risk assessment. Genomics enables identification of similarities/differences among species at the cellular level and to do the extrapolations. The default assumption in risk assessment is that we can extrapolate across species, but the literature indicates that this may not be the case. To address this, EPA is researching effects of exposure to endocrine disrupting chemicals in phytogenetically diverse species. This research is identifying/isolating receptors, determining receptor binding characteristics, then looking across species regarding the structure and function of these receptors. Structural differences have been found between genes; whether this can explain differences in binding characteristics is not yet known. When similar binding characteristics are found, such data improve confidence in extrapolating across species.

The next steps in the research program are to complete the strategic plan for the computational toxicology program, which is to be presented to the Science Advisory Board in July 2003. EPA will continue to coordinate and collaborate with other research organizations to help guide research in this area; these include NIEHS, DOE, and the CIIT Centers for Health Research. Strong collaboration and coordination with other Federal agencies will be necessary to achieve this research program's objectives as the amount of research to be done far exceeds EPA's capacity. The ultimate goal, however, is to link the science to solving Agency-related challenges.

Novel Informatics and Pattern Recognition Tools for Computational Toxicology

Dr. William Welsh, with the Robert Wood Johnson Medical School and the University of Medicine and Dentistry of New Jersey, discussed the development and application of computation tools useful to risk assessment and regulatory control, with emphasis on QSAR models. The high throughput technologies are yielding prodigious amounts of information and the mandate of the informatics tools is to digest this vast amount of data to yield meaningful conclusions and interpretations. The apparent simplicity of QSAR is that a set of compounds with common structural similarity or toxicological endpoint can be constructed on a computer, which can extract the various features (descriptors) that are in common and can correlate changes in endpoints with these features. This combines activity data and molecular descriptors to make

predictions on a larger array of chemicals and to interpret changes in biological activity (how changes lead to biological effect).

Creation of a QSAR model requires toxicological endpoints, chemical structures, calculated properties, and the use of statistical techniques to build models for prediction and interpretation. The value of QSAR models is that they are:

- Extremely fast, so they are amenable to large scale screening
- Predictive, enabling existing data to be leverage (if used correctly)
- Economical, enabling prioritization of expensive testing
- Informative, by yielding hidden patterns and insights into the mechanism(s) of action
- Humane, by reducing the extent of testing on animals.

Given the large number of untested chemicals (potentially more than 85,000), a tiered computational approach is necessary because the biological data are not available to do QSARs for each one. One approach is to consider the use of structural filters to determine which chemicals might be EDCs to identify a potential subset of chemicals, then use classification models to separate active and inactive compounds from this subset. For active compounds, the approach would be to generate data and QSAR models, and use the results to design animal studies. This approach prioritizes large numbers of chemicals with the outcome of testing the most suspect ones.

Under an NCER grant, various QSAR models were developed and applied to two estrogen receptors to explore the action of EDCs, which mimic the effects of estrogen, androgen, and other hormones and may give rise to possible adverse health effects. EDCs are highly structurally diverse, pervasive, and include both agonists and antagonists; as a result, their effects are harder to understand. The resulting data showed a high correlation between QSAR predicted binding affinities and biological measurements of binding affinities.

Receptor-based approaches look at the chemical of interest *in silico* to examine the binding geometry, use a homology model to build a structural model from crystal structure information, then "dock" small molecule compounds into the pocket and calculate binding affinities (i.e., ligand-receptor affinity and energies). The resulting data again showed a high correlation between calculated (modeled) and measured (experimental) findings for both estrogen and androgen receptors. In addition, enhanced QSAR models can be developed by supplementing QSAR models with binding energy information. Results from such models are even closer to experimental results than QSAR alone.

Research efforts also investigated the effects of certain mutations that occur within the receptor binding pocket. One example is prostate cancer in which a single mutation to alanine in one location significantly reduces the effectiveness of chemotherapy by increasing affinity of the site to a much broader range of compounds. The result changes a chemotherapy drug from an inhibitor to an agonist, an undesirable outcome.

Another research area involved the activation/antagonism of the PXR/SXR receptor by chemicals. For example, PCBs will bind to the PXR receptor and induce the generation of enzymes that metabolize the PCBs. However, activation of the PXR receptor appears to vary

species by species; PCBs turn PXR receptor "on" in rats and mice, but turns it "off" in humans. This implies that the use of rat models for PCBs may not be appropriate. In addition, different PCB compounds have different effects on this receptor and the level of chlorination appears to be the source of the difference. As an outgrowth, a series of guidelines were developed as to which PCBs may be antagonists.

Other computational tools of interest include shape signatures and polynomial neural networks (artificial intelligence). A limitation of QSAR models is the need for biological data, which may not exist. Shape signature approaches can be used to compare small molecules with one another and these differences can be extrapolated to screen and identify EDCs for example. Polynomial neural networks may be useful in developing nonlinear QSAR models for data sets that are very noisy and very large.

Computational Toxicology and Genomics: The Next Wave of Drinking Water Research

NHEERL scientist, Dr. Douglas Wolf, discussed applications of computational toxicology and genomics to risk assessment. Computational toxicology is the intersection of computational methods and the "-omics" technologies. The traditional risk assessment paradigm is that exposure at some dose results in a response that may be measured. Toxicogenomics is a new field examining how the entire genome is involved in biological responses to environmental toxicants and stressors. By combining information from genome m-ribonucleic acid (mRNA) profiling (genomics), cell or tissue protein profiling (proteomics), and genetic susceptibility, computational models can be developed to better understand stressors and disease. This results in a new risk assessment paradigm in which, at the response level, effects arising in the genome (what gene affected), transcriptome (which gene transcribed), and proteome (what protein is transcribed) can be examined to determine whether or not an adverse health effect occurs; this helps to better understand what the response is and whether it can turn into an adverse effect.

Such an approach helps to conduct better quantitative risk assessment through:

- Identification of biomarkers of exposure and response
- Better definition of dose-response curve
- Definition of mode and mechanisms of action
- Evaluation of mechanisms across species
- Construction of biologically-based dose-response models.

There are a cascade of biological, chemical, and physiological changes that result from interactions between a chemical and a biological system. For risk assessment, these toxicity pathways must be understood. While the typical toxicity pathway involves exposure, intake into organism, uptake into tissue, transfer to target cell population, cellular metabolism, cellular response, tissue response, and perhaps even organism response, the process is not straightforward and there are many pieces involved in each step.

Where genomics can have a big impact is in understanding the cellular/tissue response and predicting the response and whether there is an organ response. This helps to differentiate

between different types of toxicants (carcinogenic, noncarcinogenic). The goal is to be able to rapidly identify subsets of adverse health effects.

An example of the application of these techniques involved the understanding of the risk of urinary bladder cancer from disinfected drinking water. Chlorinated water appears to increase the risk of bladder cancer. In an experiment, bladder tissue responded to chlorinated water through cellular and gene expression changes. This experiment demonstrated the importance of moving beyond the recognition of the pattern of gene expression to turn that impact into quantitative data as well as the importance of understanding the normal biology. About half of the expressed genes involved cell structure, but other gene expression changes suggest changes in the ability of the cells to break down chemicals in the urine, which will be determined through future studies.

Another important consideration is to integrate the biology with the chemistry. Computational toxicology supports this through integration of bioinformatics and chemoinformatics to compare data on many levels, to understand altered toxicity pathways, and to compare across similar chemicals or classes of chemicals. Bioinformatics generally refers to the analysis of arrays of gene or protein expression data, and looks at gene expression patterns to determine mechanisms of action. Chemoinformatics generally refers to the analysis of chemical activity databases (e.g., results from biological assays for many chemicals) to determine and quantify relationships between chemical structure/property and activity.

Computational toxicology may also support coordinated, high throughput screening of chemicals because it is designed to interact between response profiling (genomics), virtual models (systems biology), and computational chemistry toxicity (QSAR). Thus, horizontal integration of computational toxicology approaches across ORD will support prediction, prioritization, and more quantitative risk assessment.

The Genomic Path from Exposure to Effects in Aquatic Ecosystems

NERL scientist, Dr. David Lattier, discussed research initiatives to assess risk to ecological sustainability from environmental stressors by linking aquatic exposure to physiological and reproductive effects in individuals and populations. Such data enable Federal, state, and local environmental managers to diagnose causes and forecast future ecological condition in a scientifically and legally defensible fashion, to more effectively protect and restore valued ecosystems.

Normal cell functions involve gene transcription that results in generation of a protein (the endpoint of a cellular event). Personal behavior or environmental conditions can change this process resulting in over-expression of a protein, a damaged protein, or no protein generation; this results in a non-normal endpoint that can affect reproduction, development, and/or overall organism sustainability.

Gene expression studies are using the fathead minnow because it is easy to distinguish males and females, the species is hardy and found throughout the lower 48 states, it has rapid generational turnaround (reproductive maturity in 4 to 5 months), and over 30 years of toxicological data exist for this species within EPA.

While many genes are expressed at equal levels in all cells (so-called housekeeping genes), a subset of genes can be identified that are specifically activated by a certain environmental stressor or class of stressors. This may be useful to link exposure to population and reproductive effects as well as evaluating effectiveness of remediation technologies and characterizing exposure of aquatic organisms to mixtures.

A single gene indicator for estrogenic aspects of water, the *Vitellogenin* gene, has been in use for several years. While this gene is normally expressed only in egg-bearing females, gene expression can be environmentally induced in male fish. Thus, this gene is an excellent indicator of estrogenicity in aquatic ecosystems.

The genomic aspect gets involved when moving from consideration of one gene to the consideration of many genes. By extracting and covalently binding hundreds of genes to a microscope slide, which is then washed with a chemical of interest, microscopic examination can identify changes in gene expression (up and down regulated) as well as those with no change in expression. Bioinformatics is then used to look at the patterns to see which genes are grouped in functionality. Proteomics can also be used to profile the proteins. If done correctly, genomics can yield a genome-wide, hypothesis-free snapshot of dynamic biological systems.

Ecotoxicogenomics is another field in which microarrays can be used to determine bioavailability, generate molecular signatures and patterns of gene induction by classes of toxicants, and aid in structural characterization of exposure-specific up-regulated genes.

The overall goal is to enhance computational toxicology through the use of genomics, proteomics, and metabonomics to assess single stressor exposure patterns, and to describe the predictive and mechanistic biology of environmental stressors. The challenges faced in this area are which genes become up regulated and the functional significance of that change, defining individual variability and its relationship to gene expression, impacts of complex mixtures of stressors, and cross-species extrapolation.

Structure-Activity Tools for Assessing Pesticides and Toxic Substances—Past, Present, and Future

Mr. Joseph Merenda Jr., with the OPPTS Office of Science Coordination and Policy, provided the Program Office perspective on the use of structure-activity tools, the types of tools in use, and the gaps/needs to fill. Structure-activity tools are a core technology in OPPTS programs. While not widely used, they are a key component of many activities, including:

- Hazard screening for new industrial chemicals, e.g., pre-manufacturing notifications under the Toxic Substances Control Act (TSCA)

- Setting priorities for chemical testing (e.g., high production volume chemicals, EDCs), including a mandate under the Food Quality Protection Act to screen and test a large number of chemicals

- Promoting pollution prevention through selection and design of reduced-risk chemicals and use of PBT profilers with the goal of better communicating technologies to the private sector and encouraging their use as new products are developed.

Applications of structure-activity approaches include identifying properties of homologous chemicals, correlating narcotic potency with partition coefficient, estimating chemical properties using structural features (through correlative, mechanistic, and structural techniques), and screening/discovering drugs. These involve three families of structure-activity approaches: expert-based, regression-based, and molecular modeling.

Expert-based structure-activity approaches draw on past experience in evaluating structure, analogs, and mechanisms to determine what hypotheses can be developed, to conduct qualitative hazard prediction, to determine whether laboratory (*in vivo*) testing is necessary, and to determine whether there is a concern that warrants regulatory activity. An example of the application of this approach is in the health effects analysis for pre-manufacturing notifications.

Regression-based structure-activity approaches can be used to estimate ecotoxicity for new chemicals, and require regression models for relevant chemical classes. This approach is primarily applicable for non-specific toxicity. The octanol-water coefficient appears to be the best predictor to date, and there are some techniques applicable to situations where there is little to no data.

Molecular-modeling structure-activity approaches require extensive knowledge of the toxicity mechanism at the molecular level. The approach is promising but not yet in use, and it is being evaluated for endocrine disruptor pre-screening and priority setting.

The reasons to invest in better structure-activity tools include: (1) the need for better, more targeted testing to address huge data gaps, resource limitations, and animal welfare concerns, (2) the need for tools that incorporate the rapidly advancing genomic knowledge, and (3) the challenge of addressing real world exposures to multiple chemicals and other stressors.

NIEHS Toxicogenomics Centers: Model for Partnerships

Dr. Bennett Van Houten, Chief of the Program Analysis Branch at NIEHS, discussed the Toxicogenomics Research Consortium (TRC) and the use of partnering to fully utilize the potential of toxicogenomics. The NIEHS National Center for Toxicogenomics was established about 2½ years ago to combine toxicology with gene expression profiling, proteomics, metabonomics, and single nucleotide polymorphism analysis using a relational database. As part of this Center, the TRC consists of cooperative research members (five academic centers and the NIEHS microarray center), two large resource contractors, and extramural staff.

The primary TRC goals are to enhance research in environmental stress responses using microarray gene expression profiling, provide leadership in toxicogenomics by developing standards and practices for analysis of gene expression data, develop a robust relational database, and improve public health through better risk detection and earlier intervention in the disease process. TRC cooperative research members work on common problems, send RNA and other data to the contractors, who provide microarray and bioinformatics support, then the consortium

develops practices and standards for common adoption for data generation and submission to the database. The contractors deposit the data into the NIEHS chemical effects in biological systems knowledge base that NIEHS hopes will become a resource for the research community.

Use of centralized contractors was key to information flow and facilitating the communal work of scientists at different locations and academic centers. Each academic center has three funding areas: core support, toxicology experiments, and basic research using gene expression profiling.

To build this standardization project, a common language (standard) was created for gene expression experiments to generate high quality data and to compare/compile data across multiple microarray platforms and laboratories. Otherwise, the many sources of variation in microarray experiments and in the application of bioinformatics tools make it difficult to compile and compare data across different databases. As part of this effort, an experimental protocol was developed and implemented at the academic centers to determine variation in RNA labeling and hybridization. Analysis is currently underway regarding data reliability, reproducibility, and quality. The program used common genes across the platforms as well as genes on the standard chips generated by each academic center. Other areas of interest include sources of technical variation such as direct versus indirect labeling, background correction, image analysis and raw image processing, normalization, and probe performance (for the same genes).

Preliminary findings show a high correlation of results within one microarray, but this correlation decreases for the same sample analyzed within different microarrays, and decreases even further when two different mice species are involved. Generally good correlation was found within individual academic centers and less correlation across academic centers. Use of different scanners also influenced results and correlation improved when the different academic centers used the same scanner.

These results indicate that development of standards for gene expression experiments are necessary for a number of reasons. Large amounts of standard RNA (single tissue, mixed tissue) are necessary and must be reliable, reproducible, and stable over time. In addition, quality control genes need to be included on chips for analysis, a list of predictive genes is needed that can hold up across platforms (species-specific, universal), and common gene annotation is necessary (e.g., accession number/Unigene cluster, sequence information, commercial arrays).

The TRC projects are a partnering opportunity for academic centers to work together and eliminate variation in gene experiments. Information gained by TRC will be used by individual sites and 600 grantees to move the field forward in industry as data become available. This effort envisions the generation of standards and best practices to enable data comparison across platforms, to develop a microarray library, and to develop a Chemical Effects in Biological Systems knowledge base. These will all support the use of toxicogenomics to improve public health by:

- Enhanced efficiency in toxicity assessment
- Enhanced efficiency in drug design/safety assessment
- Individualized medicine for prevention, diagnosis, and treatment
- Individualized risk assessment.

Panel Discussion/Questions and Answers

The speakers had an opportunity to participate in a brief panel discussion drawing on questions from the audience.

A brief question and answer period addressed a range of topics. These included: (1) limitations of current technology to conduct high throughput assays for analysis over time, which results in "snapshot" results (one sample result in time) that may affect our ability to distinguish between normal variability in gene expression and the response to a stressor; (2) the potential for more extensive use of quantum mechanics, associated limitations regarding molecular features that may be evaluated through QSAR, proteomics, and genomics, with a future vision of combining all of these techniques to understand the properties of chemicals and especially small molecules; (3) differences in the state of the technology in application by drug designers/discoverers, who are looking for a very specific therapeutic outcome and know what receptor to target, as well as the application in environmental toxicology where the chemical decides the binding point; (4) whether such techniques will be able to address large ecosystems where habitat issues may be more important that chemical concentrations and the use of historical approaches (such as EMAP) in conjunction with the "-omic" techniques, stressing the importance of distinguishing between adaptive responses and damage from stressors; (5) expectation that chemical approaches and the various "-omic" approaches will merge over time with the example offered of the use of genetic approaches to understand population dynamics and impacts of resistance incorporated into plants to establish a baseline for population density, gene flow, and diversity to support analysis of the effects of genetically-engineered crops on nontarget organisms; and (6) the ability of large databases to look at normal as well as toxicological changes including the impacts of animal care and feeding on the genetic level and gene expression as well as the use of pathways approaches for an ecosystem rather than gene-by-gene approaches.

In closing, Dr. Farland noted that all of the session discussions presented examples of the values of partnerships.

Innovation to Advance the Detection of Threats and Optimize Environmental Decisionmaking

Following opening remarks by Dr. Gary Foley, with NERL, six speakers addressed innovative technologies and tools understanding the human health and environmental effects of chemicals. A panel discussion including an audience question and answer period followed the presentations.

Information Technology Science: Bolstering the EPA's Mission

NERL scientist, Dr. Gary Foley, welcomed session attendees and discussed the complexity of issues to address in protecting human health and the environment. There are a number of aspects to consider including development, wildlife, sensitive human populations, soil, air, a vast range of scales (cellular to ecosystem and global), a breadth of alternatives, and a myriad of uncertainties.

Given these complexities, advanced information technology and modeling are essential to gather, integrate, and interpret (layer) data; combining data with modeling to predict changes to exposures and from regulatory actions as well as understand the underlying issues; predicting outcomes by combining all of this information such as evaluating PM2.5 regulatory strategy impacts on contaminant levels and resulting changes in exposure; and bringing in decision tools to help make multi-stressor regional decisions. These tools and approaches enable EPA to make progress on critical issues such as clearer skies, cleaner water, more vital ecosystems, and reducing impacts by understanding actions at the molecular level. All this can be combined to understand how to make people healthier around pollutants and to predict risks.

Meeting National Environmental Goals: Coordinated Federal Information Technology Solutions

Dr. David Nelson, with the White House National Coordination Office for Information Technology Research and Development, provided an overview of the Federal Networking Information Technology Research and Development Program and provided several modeling examples of Federal agency partnering. Since 1991, this Program involves coordinated, focused, long-term interagency research and development in information technology involving 12 agencies and departments. Activities encompass high-end computing, large-scale networking, high confidence software and systems, human-computer interaction, software design and productivity, and social, economic, and workforce implications of information technology. Examples of environmental-related information technology research include simulation of aquaporin protein function in a cell to transport water molecules (NSF, NIH), environmental modeling of the Chesapeake Bay (NOAA, EPA, DOD), high-resolution, long-term climate modeling (DOE, NSF, NOAA), and "smart dust" (DOD and Intel).

Aquaporin is a common protein in mammals that controls water flow in and out of a cell. If this protein mutates, it does not function correctly and can lead to serious health outcomes; the protein may have a role in glaucoma and diabetes. Visualization was used to understand the function of this protein and determined that the water molecules flip position, first entering the cell membrane to a certain point via the oxygen molecule then flipping to complete entry via the hydrogen molecules. Experiments would have been unable to obtain such information on cellular phenomena at the molecular level.

Modeling and visualization were combined in evaluating the salinity in the Chesapeake Bay. The computed salinity was visualized and the model used to compute salinity was checked against measured data such as dissolved oxygen. This approach was useful for data analysis by users that were not skilled computational scientists. The results indicated that a significant portion of the nitrogen enters the Chesapeake Bay via air pollution from sources located hundreds of miles away from the watershed. Therefore, to control nitrogen, both air and water quality needed to be addressed. This illustrates the use of modeled information to inform and advise regulators and policymakers.

One long-term climate modeling example included a 1,200 year control run of existing and extrapolated climate data to evaluate the El Nino cycle. The model found large variability in the cycle, identified periods where the cycle diminished in intensity, and determined that there are natural cycles that must be considered in addition to greenhouse gas impacts for global climate

change analysis. A second climate modeling example involved the simulation of a tropical cyclone near Madagascar that demonstrated the power of a Japanese earth simulator for better resolution of local features. This effort found significant differences in resolution based on grid size, with the smallest size providing sufficient resolution to clearly visualize the cyclonic pattern. These results demonstrated that for climate modeling, a smaller grid size is necessary, which in turn requires more data points and larger computers for analysis. This simulation shows that computers can be used to conduct regional analysis using models run at global scale.

"Smart dust" is a research activity being conducted by the University of California, Berkeley with a near-term goal of developing a millimeter-sized sensor and communication package using radio frequency, laser, and modulated corner reflector for communications and sensors. These would replace current sensors that are largely mechanical. The small size would facilitate broad distribution for environmental monitoring or surveillance. In an experiment, an aircraft dropped a number of such sensors equipped with magnetometers and radio frequency communications along a road on a military base and the sensors were able to sense the passage of vehicles, spot traffic patterns, and communicate the speed and size of vehicles. In the next 10 years, these may be useful as pollutant sensors in the environment.

Other examples of information technology applications to environmental issues include combustion modeling to reduce emissions, transport modeling of toxic plumes, hydrology models of surface and groundwater, networks of real-time sensors to detect toxic chemicals or biologicals, digital libraries of mass spectral prints for chemical compounds, models of biological activity of toxic chemicals, and information on genetic mutations due to chemicals. These examples illustrate how the use of information technology can confront environmental problems perhaps faster than through other techniques and with a sound basis in science.

Application of Advanced Information Technology to Promote, Educate, and Address Environmental Concerns

Ms. Ramona Trovato, with EPA's Office of Environmental Information, discussed EPA use of information technology to manage incoming information and to use that information to make good decisions. EPA has collected information for diverse programs for a long time. Approximately half of EPA's $7.5 billion budget goes to states to carry out the environmental programs, which in turn requires information to come back to the EPA. There is also the need to share information with the USGS, NOAA, and other partners.

Key issues are the need to obtain and disseminate timely and quality data for EPA and its partners, the need to disseminate data to the public in an easily understandable and usable form to help make decisions and to get involved in issues, and the need to use the collected information in sophisticated ways to better understand the environment.

The National Environmental Exchange Network is a recent initiative that is a different way of sharing data via a standards-based, secure exchange environment. There are many legacy databases, and much of the data may be old with data updates occurring as the states are able or willing to do so. The new system enables rapid data access and looks across programs rather than following the traditional statutory "stove pipes." The overall goal is to exchange more information across more users by improving data quality and reproducibility, reducing the

burden for all partners, improving public and regulator access to data, ensuring data stewardship, and improving the timeliness of quality data availability.

Approximately 40 states are currently participating in this network, which primarily involves air data. The network includes data standards for data elements such as latitude and longitude, and also includes metadata (critical associated parameters) that help modelers and others with data analysis and in understanding data anomalies. The network will include partner network access nodes as well as data exchange templates to facilitate data sharing and more frequent data updates.

EPA also disseminates data to the public via its website, which is being modified to facilitate searches on topical information. Pages are being added to the website to focus on topics such as the Mercury Portal Project and these will form the basis for more in-depth topical searching. Another change will be the addition of the ability to integrate, organize, and analyze information from EPA, USGS, and others for geographic location(s) of interest to the user. This will enable the public to look at their particular area of interest to see what is occurring, view aerial photographs, and access information on water, air, and waste. Envirofacts is another tool for information dissemination that is focused more on the scientists and data analysts.

EPA is also using information technology to analyze and use data. An example is the use of high performance computing (i.e., supercomputers) that enable more variables and conditions to be addressed and facilitate data visualization. An example is the Cyberlung Project in which EPA developed a model of the lung and how it works, and uses fluid computational dynamics to understand how the lung takes in and processes PM. This will contribute to greater understanding of lung diseases such as asthma, which is the leading cause of children's absence from school. Another example is a three-dimensional physical model of Manhattan built to better understand human exposure to urban microenvironments from the aftermath of the terrorist attacks on the WTC. High performance computing supports this effort and the extrapolation of this understanding to other cities.

A final example is the EPA Indicators Initiative supporting the State of Environment Report. The purpose is to answer questions about the environment an health by looking at air, water, land, and ecosystem to define environmental indicators that in turn will help EPA to define the issues and prioritize funding – a clear example of using scientific knowledge to help resolve issues.

Monitoring Stressors to Human and Ecosystem Health from Space

Mr. David Williams, with ORD, discussed the use of remote sensing data acquired from satellites to support EPA and global climate change issues as well as atmospheric scientists and modelers. A number of space-based satellites exist today that are already collecting data that can be used for determining air quality, understanding landscape change, measuring atmospheric constituents, and monitoring natural and technological hazards (oil spills, fires). There are over 1,800 active earth orbiting satellites. While most are for communications or GPS, 56 have earth observing remote sensing systems of which a few have high resolution reconnaissance technologies or all weather capable imaging radar sensors.

Measurements obtainable from these satellites include earth surface imagery from 0.6 meters to 1 kilometer resolution, infrared to thermal energy, passive and active microwave, atmospheric constituents (ozone, methane, aerosols), and the ocean. Examples of the use of such remote sensing data include landscape change such as the urbanization of the Las Vegas valley over time, which enables assessment of impacts on the ecosystem as well as health impacts of urbanization. City light data can be used to map human populations; while the United States has extensive census data, population sizes in other global locations are not as well known and this information is important to understanding growth. Thermal imagery can assist with geological mapping since different rock types will show as different colors. In addition, passive microwave sensors assist with rainfall mapping which in turns helps us to understand rainfall intensity.

Such remote sensing data imagery is a tool for scientific research and data analysis including human and ecosystem health monitoring. However, a satellite image is an array of numbers and computational techniques can analyze those underlying data for a variety of purposes. Possible examples include:

- Impacts of rangeland on water quality in arid environments using satellite imagery to detect vegetation changes over time and to develop a monitoring plan by combining climate data and land use information

- Detection of invasive species drawing on differences in how plant species "green up" during the year

- Effects of landscape imperviousness on stream biology using satellite maps of land cover, determining impervious areas (estimation of percentage not available from traditional maps), and combining this with water quality, hydrographic, and topographic data

- Monitoring natural and technological disasters by providing daily imagery from multiple satellites to response teams, or combining the imagery with population data to map regions where people have been exposed to hazardous materials

- Air quality monitoring using satellite observations (for daily aerosol optical depth measurements) in conjunction with web-based maps to show regions of human exposure to unhealthy levels of pollution.

Jim Szykman, with OAQPS, discussed current research efforts in conjunction with the NASA Langley Research Center to incorporate data into remote sensing modeling. This example involved a data fusion demonstration to bring together two data sets for September 2000 – one from sensors on satellites and one that is state/local to measure aerosols – in order to relate satellite data to ground level PM2.5 concentrations. This effort combined hourly PM2.5 measurements from ground level monitors, daily optical depth imagery (for total loading of aerosols within the atmosphere) from a polar orbiting satellite, and daily cloud optimal thickness (from satellite). The overlay of these data and their animation over time visualized the transport of the change in PM2.5 that moved from the Midwest into the Texas/Louisiana/Gulf of Mexico area and demonstrated the correlation of the satellite and ground data, while providing additional context to understand what is occurring.

ASPECT: Protecting Americans Through Rapid Detection of Atmospheric Contaminants

Dr. Mark Thomas, with EPA Region 7, presented an airborne technology in use by EPA to assist with emergency response to incidents involving chemical releases. EPA is tasked with providing a very rapid chemical detection capability to chemical emergencies as defined in the National Contingency Plan and is developing tools to assist with this mandate. From the perspective of an OSC, emergency situations require direct integration with the local incident commander, near-real-time collection of data, aerial photography capability (to visualize the entire situation), basic telemetry to transmit information, and the ability to detect chemical plumes coupled with automatic data processing that does not require sophisticated scientific technology. EPA developed such a capability drawing on a standoff battlefield chemical detector originally built by the Army that evolved into the Airborne Spectral Photographic Environmental Collection Technology (ASPECT). This system has assisted with EPA response to 12 incidents to date including the Winter Olympic games and the recent space shuttle disaster (to look for monomethylhydrazine).

The ASPECT system consists of a very stiff, high wing aircraft equipped with two primary sensors: an infrared line scanner to image a plume and an airborne Bomem high speed spectrometer. These systems are networked together in conjunction with a variety of GPS feeds to provide special coordination. ASPECT also includes high-resolution aerial photography, videography, and a special link to transmit information between the aircraft and the ground using a telemetry unit that can be parachuted to a ground team to set up and operate with a 2-mile coverage using wireless Ethernet. The unique infrared system is designed to obtain four sweeps of the ground through one rotation with two calibration points for each sweep.

Gyroscopic response measured during flight is used to make corrections to the information. Data processing includes radiometric calibration and correction capability for pitch/roll, yaw, band overlay, vibration (jitter), and geo-rectification (to show north at the top of the image and for compatibility with GIS packages).

To enable faster access to spectrometer data, signal processing approaches developed for radar systems are used to create a band pass filter to look only at the analytes of interest using information collected from the interferogram stage rather than continue the data processing from the interferogram using fourier transforms. This approach eliminates background interferences such as ozone.

The ASPECT approach is designed for addressing larger volume chemical spills rather than parts-per-billion air releases from landfill caps. Ongoing ASPECT enhancements include sensor upgrades to provide better throughput, expansion of the compound library, aerial photography enhancements, and oil and radiation detection capability.

Simulation and Visualization of the Smoke/Dust Plume from the World Trade Center

NERL scientist, Dr. Steven Perry, discussed laboratory simulation of smoke/dust plumes and air pollutant transport from the collapse of the WTC in New York City. The purpose of this

simulation is to characterize the temporal and spatial patterns of contaminant concentration/deposition to support risk assessment of potential human exposure from this several month long pollution event, and to improve understanding of pollutant pathways in urban areas. Computer simulations are necessary in these situations because of the complex nature of the urban environment and laboratory efforts are necessary to validate such models. In turn, an urban computer modeling tool can support improved air quality estimates from routine emissions such as from urban traffic, risk assessment, and emergency response.

The laboratory simulation involved the creation of a three-dimensional digital representation of the WTC and surrounding buildings in the Lower Manhattan area of New York City using data collected prior to September 11, 2001. A time series computational fluid dynamics simulation of the WTC north tower collapse was conducted to show the change in the pollutant plume flows over time (during and after collapse). Comparison of the dispersion model simulations with satellite imagery of the WTC plume showed many similarities.

A number of studies demonstrate the influence of urban structures on dispersion model results. An EPA computational fluid dynamics simulation of carbon monoxide from vehicle traffic in Manhattan showed complex mixing and differences from street to street. Los Alamos National Laboratory (LANL) modeled a pollutant release in Portland, Oregon, that considered both the presence and absence of buildings in the vicinity; the presence of the buildings resulted in significant changes in pollutant plume flow and contaminant distribution. Another LANL simulation involved the Urban 2000 experiment in Salt Lake City to determine plume transport to help emergency responders identify safe areas; this simulation found that even after the source was turned off, pockets of pollutants remained in downtown areas and even an hour or more after the "event" that strong pockets of pollutants remained elsewhere in the city.

To better evaluate these types of findings, EPA conducted a wind tunnel study of Lower Manhattan in order to develop a controlled laboratory database that characterizes local flow and pollutant dispersion regimes. Potential uses of such a database include computational fluid dynamics model improvement and evaluation, characterization of urban concentration patterns possibly as a source term for regional models, and development of emergency responder "rules of thumb" and engineering approaches for quick response (e.g., quick response models).

This study involved the creation of a scale model of Lower Manhattan for use in a wind tunnel for testing. The scale model was created from the digital building geometry data, satellite photographs, and actual photographs to develop the geometry of the WTC rubble pile. Three major components of the study included visible smoke visualization, flow characterization in street canyons (measured velocity and turbulence using laser Doppler velocimeter), and tracer concentration measurements in street canyons and above the city. The simulation for the first component focused on the smoldering fires and fugitive dust that continued on the WTC site for weeks after building collapse, and used both smoke visualization and lasers to see flow and circulation. Preliminary results indicated that the remaining buildings caused the plume flow to turn and eventually move up other streets in the opposite direction of the main plume flow, which would affect occupants if such buildings have fresh air intakes on their rooftops (safe buildings aspect).

These studies are underway and the results will be linked with air pollution monitoring and regional scale modeling to develop potential human exposure patterns. This will serve as an important component in EPA's urban scale and emergency response model development programs.

Real-Time Monitoring and Communication of Air Quality

Mr. Timothy Hanley, with the EPA Office of Air and Radiation, discussed efforts to communicate real-time air quality information to the public. Under EPA's Air Quality Index (AQI) program, EPA provides daily reports on the AQI results for the previous day; these include ozone, PM, carbon monoxide, SO_2, and NOx. The AQI is important because it is the single best tool to communicate air quality to the public for ozone, and soon for PM, via the media. The AQI links air quality levels and a health message, increases the role of state and local agencies, promotes voluntary forecasting, and is a useful public service. The AQI has color codes ranging from green to red (good to very unhealthy, respectively) that focus on air quality and health implications, and includes separate cautionary statements for ozone and PM in each category; ozone cautions distinguish between indoor and outdoor considerations whereas PM cautions do not. Each person is affected differently by the air quality. Individual effects can occur even if air quality levels are in the moderate category. As a result, the system has been enhanced to include cautionary statements for that category as well.

AIRNow is a voluntary program that provides a national vehicle for exchange of real-time air quality data and forecasts using the AQI. The initial focus was on ozone and is now moving to include fine PM (PM2.5) and may soon include PM10 data, which are important for forecasters to predict the next day's AQI.

AIRNow is a cooperative effort between EPA, NPS, state, and local air agencies to collect, quality assure, and transfer real-time and forecast air quality information to the public. This is intended to provide the public with fast and easy access to understandable air quality information to assist individuals in making health-based decisions about daily activities.

Visualization is an important tool for forecasting air pollution. The most important report is the daily forecast because it affects how individuals might schedule their activities for the next day. Data become available in the afternoon, scientists make a prediction for the following day creating a forecast map sent out to the media as a public service. If enough large cities participate, the big media services are willing to disseminate the information, and once one large media organization begins publishing such data, the others will follow.

State, local, and other participating agencies gather the data from their monitoring networks and transfer the data via dial-up modems or broadband telemetry systems to the AIRNow Data Management Center. Quality control checks are performed using a variety of techniques and mapping domains are produced on a defined schedule once a minimum number of states' data are received. Current activities include more rapid transmission of data to the Data Management Center, which will require some cities/states to invest in more modern transmission systems.

In 2002, AIRNow had nearly national coverage for real-time ozone mapping. In 2003, AIRNow is moving towards overlaying fine PM (PM2.5) and ozone data with an educational/media

outreach program for PM2.5. Data are coming from many locations for nationwide coverage as well as portions of Canada, particularly southern Ontario. In October 2003, EPA will launch a national campaign to kick-off year-round AQI.

Longer-term goals include the development of a National Air Quality Forecast Model in partnership with NOAA, providing web-based access to all data coming into the AIRNow database, and providing stakeholder access (technical personnel rather than general public) to AIRNow database. Supporting activities include the resolution of technical issues for real-time reporting and mapping of PM2.5 (for example, averaging 3 to 6 hours of data rather than waiting for 24-hour results), AQI forecasting activities and piloting efforts in 36 major cities in the United States, and funding state/local government agencies to develop PM2.5 forecast tools.

AIRTomorrow is an initiative addressing forecast models to provide national coverage for both urban and rural areas. This will be a long-range tool for use by experienced and inexperienced forecasters that might be run as one of several forecast components in a large city but might be a default forecast for smaller cities/areas. A visualization of PM2.5 concentrations was run for August 2002 when a significant regional transport/stagnation pollution event resulted in high levels of ozone, PM2.5, and other secondary pollutants. This visualization showed fairly good correlation of resulting haze with that shown on an aerial photograph for the same time period.

Panel Discussion/Questions and Answers

The speakers had an opportunity to participate in a brief panel discussion drawing on questions from the audience.

A brief question and answer period following the early afternoon sessions addressed a range of topics. These included: (1) use of remote sensing information to aid in planning the national air monitoring network and consideration of dead zones (e.g., areas with no monitoring); (2) consideration of the use of airport visibility and other monitors in conjunction with remote sensing to enhance estimates of air quality; (3) the relationship between the environmental indicators project and the Report on the Environment (formerly entitled the State-of-the-Environment Report); and (4) methods for enhanced, computer-based information exchange including issues associated with firewalls, timeliness of future data accessibility, and ability to distinguish between computer-based attacks and friendly user access.

A brief question and answer period also followed the later afternoon sessions and addressed a range of topics. These included: (1) level of resolution for infrared imagery from the ASPECT system; (2) viewpoints on use of unmanned vehicles for monitoring to support emergency response activities; and (3) measuring success of AQI predictions, the level of public knowledge about the AQI, and how individuals take action to change their activities to reduce exposures or their contributions to air pollution during elevated levels.

Applying Biotechnology to Achieve Sustainable Environmental Systems

Following opening remarks by Dr. Hugh McKinnon, Director of NRMRL, seven speakers addressed various types of biotechnology, current research, and existing as well as potential

biotechnology applications. A panel discussion including an audience question and answer period followed the presentations.

The Director of NRMRL, Dr. Hugh McKinnon, welcomed session attendees and provided a general session overview.

Molecular Farming for Sustainable Chemistry

Executive Director of the Fraunhofer Center for Molecular Biotechnology, Dr. Barry Marrs, discussed the use and implications of molecular farming, which is the use of plant biotechnology to advance protein expression. The use of biotechnology to manufacture chemicals is advancing faster than many realize and may have significant changes on both the chemical industry and the programs that ensure manufacturing is conducted safely. This represents the third wave of biotechnology (industrial chemicals) with the first wave involving pharmaceuticals and the second wave involving agricultural chemicals (currently in progress).

The industrial applications of biotechnology involve the use of industrial biocatalysis to manufacture chemicals and materials. This is an attractive technology because its benefits include cost-effectiveness (less expensive catalysts), cleanliness (less waste, therefore, less expensive), and sophisticated chemistry. Challenges include the current limited availability of enzymes for the purposes desired, the need to renew the enzymes (e.g., they have limited lifetimes), and process development (a cross-disciplinary effort involving engineers and biochemical scientists).

There are several powerful technology drivers that will accelerate the use of biocatalysis in the chemical industry. First is finding better catalysts in nature through expression cloning and other techniques; the vast majority of existing organisms cannot yet be cultivated and new technology is developing to enable us to cultivate many more microbes than is currently possible. Second is the use of directed evolution to improve upon catalysts already found in nature; nature designed proteins to function within specific parameters (e.g., water, temperature) and to produce specific proteins (enzymes) for specific functions. Current laboratory techniques are able to change the enzyme produced; for example, to work faster. Third, low cost manufacturing through development of large-scale production techniques; for example, molecular farming may be able to make an enzyme for a portion of the cost of more traditional fermentation techniques.

The specialty chemical industry is experiencing the leading edge of this third wave of biotechnology, which is a young science. Several examples were provided of specialty chemicals produced using various biotechnology techniques. In one case, a comparison of the chemical and biotechnology production of L-carnitine demonstrated significant reductions in the quantities of waste to be managed as well as significant changes in the waste stream constituents. Since biological proteins are designed by nature to create a specific product with few to no byproducts, rather than a range of products, there is less waste and therefore less associated waste management costs.

This is a new, evolving technology and change comes rapidly. Countries and companies that do not embrace the new technologies are vulnerable to replacement.

Industrial biocatalysis will have a smaller environmental footprint than conventional chemistry-based manufacturing approaches. This may result in the need for more emphasis on ecology (e.g., eutrophication) and less on toxicology and different types of exposure analysis. For example, a consideration of the consequences of consuming a corn product containing an industrial enzyme and how to safely produce low-cost biocatalysts in field crops. Bioremediation may also become more powerful driving considerations of secondary consequences to the environment, such as what happens to the biological once its "job" is done. A major challenge is the lack of an ecological testing system, such as long-term ecological testing parks, to support research in these new areas of consideration.

Directed evolution involves engineering an enzyme and engineering a plant to produce the enzyme. An example is the use of oxidized guar to improve the wet strength of paper. Only one enzyme in nature produces this compound, galactose oxidase. Since there are limited amounts in nature, the enzyme is expensive. Using directed evolution, larger volumes could be produced resulting in a dramatic price decrease. Directed evolution involves the selection of genes to improve, creation of a library of variants (mutations), insertion of the gene library into an expression vector, insertion of the library/vector into a bacteria to produce enzyme variants, screening the resulting colonies for improvements in the properties of interest (e.g., more productive), isolating the improved gene(s), and repeating the process until improvement is achieved. Multiple cycles will significantly reduce the overall improvement in properties.

Molecular farming involves two techniques: transgenic plants (a method of direct expression of foreign genes in plants) and plant virus vectors (method for transient expression of foreign genes in plants). The latter technique is faster (and therefore less expensive) than raising plants, but the trait is not inherited and there are issues associated with virus transmission. These techniques are most suitable for greenhouse environments using non food crops rather than planting fields.

In summary, nature created an incredible array of enzymes that serve as catalysts. Tools of directed evolution can quickly create new enzymes, including those suitable for industrial applications. Molecular farming can produce enzymes at much lower cost than fermentation techniques. Life cycle analyses for such plant techniques have not yet been performed and would need to consider energy consumption as well as potential reductions in greenhouse gases (plants consume CO_2). Results are expected to be favorable as compared to fermentation.

EPA Biotechnology Program Overview

NHEERL Director, Dr. Lawrence Reiter, presented an overview of the EPA biotechnology research program, the scientific framework that is shaping and driving the research, and research approaches to address key scientific issues. Dr. Reiter also discussed the ORD research initiated to address the growing use of agricultural biotechnology products and the EPA pesticide program responsibilities to regulate them.

There has been a huge growth in acreage of genetically modified crops worldwide since 1996 with the number of countries involved in this effort doubling over this time period and the United States continuing to be the major grower. EPA has a regulatory role in the area of genetically modified crops through FIFRA, which establishes the requirements for EPA to review and register all pesticides used in the United States including DNA used in plants for pesticidal

protection purposes. FIFRA includes an obligation to ensure that these pesticides will not pose unreasonable risk of harm to human health and the environment. Many reports address modified crops and three general recommendations form the basis for the EPA research program: assessing allergenicity risks from genetically-modified crops, assessing the possibility for gene transfer and ecological risks associated with such crops, and managing gene transfer and resistance.

Food allergies are not uncommon and are more prevalent in children than adults. The novel proteins introduced into food through bioengineering could be allergens. The research need is for a rodent model to evaluate allergenicity of genetically-modified crops, explore susceptibility, and understand age-related differences in allergy occurrence. Ongoing research is identifying allergenic proteins in indoor mold, developing an animal model, and measuring the development of the allergic antibody IgE and eosinophilic inflammation (the allergic response). Ultimately, the model will be adapted to the study of food allergens and to identify the immunological responses in the gastrointestinal system to understand mechanisms, potency, and vulnerability.

Areas of ecological risk research needs include understanding the likelihood and impact of gene transfer, characterizing impacts of crops on non-target species, and determining/managing pesticide resistance. Research to evaluate gene flow from genetically-modified crops include the potential for transfer of novel genetic material to non-target plants and whether gene transfer confers traits onto non-target plants that change how the plant fits into an ecological system and the potential for unintended ecological consequence. This involves the need to develop methods to identify gene transfer, movement, and expression, which is occurring in the Corvallis, Oregon, laboratory. Genomic techniques are being designed to study gene flow from transgenic plants and to design molecular markers to detect transgenes in plants. The next step will be to identify the target genes in the transgenic plants. Research efforts focus on canola and creeping bent grass because they are grown in close proximity to a wild relative (therefore a potential exists for gene transfer) and the modified plants are available for study. Greenhouse studies of the modified plants and wild relatives will aid in understanding the biological and nonbiological factors in gene flow, including evaluation of the fitness and ecological effects of crops and non-crop hybrids on growth, seed production, and other factors affecting species survival and diversity.

The goal of research to identify impacts on non-target organisms is to develop genetically-based approaches to monitor non-target populations to determine if exposure has occurred and the impact of such exposure. This will involve evaluation of sites near both traditional and Bt agro-ecosystems (corn, cotton) to establish baseline measures for population structure followed by monitoring over time to determine whether these structures are modified by the presence of the Bt crop. A first step is to develop novel methods for sensitive exposure monitoring using gene markers, development of genetic methods to evaluate population structure (size, density) and gene flow, then measuring temporal patterns in population sizes and allele frequencies of response genes to see if exposure occurred. Utility of the monitoring program will be assessed after three years then turned over to the EPA Program Offices, Regions, and states for long-term monitoring aspects.

The last area is resistance management. Resistance evolution in insects is common, and OPP recognizes this concern and requires the development of resistance management plans to prolong

the usefulness of Bt crops, to avoid the need to return to broad-spectrum pesticides, or to render ineffective the Bt spray applications for organic farming. For resistance management, EPA requires implementation of a high dose, structured refuge strategy so that there is some portion of the Bt crop field that is set aside to grow the non-Bt crop with enough dose in the modified plants to kill the targeted insect. Resistance management is a model-based approach that is also dependent on accurate biological information (such as local insect population sizes, dispersal patterns, and mating patterns) collected using genetic markers. Models also depend on the genetics of resistance (number and importance of genes), therefore laboratory studies will be conducted to evaluate chromosomal distribution of resistant genes. Tools will also be used to identify the emergence of resistance in the field in order to put in place corrective actions.

Regulatory Perspective on Bioengineered Crops

OPPTS/OPP scientist, Dr. Janet Andersen, discussed the role of science in the regulation of biotechnology. Regulation of biotechnology products requires a strong scientific base, and scientific research improves the regulation of such cutting-edge technology. For OPP, this draws on scientific expertise from Program Office programs, research support from ORD, and outside peer review by the FIFRA Scientific Advisory Panel.

Science supports regulation by identifying possible risks/benefits. OPP considered data requirements, appropriate mitigation, the types of data and studies needed, scientifically-valid protocols for conducting the studies, and standard protocols for conducting reviews, models, and monitoring. The goal was to monitor for what is actually occurring in the field since bioengineered crops are an important public policy issue worldwide. Decisionmaking based upon the scientific data will vary from country to country due to cultural and environmental differences. However, an international organization, CODEX, has adopted the United States' approach to risk assessment of plant incorporated protectants and foods derived from biotechnology, and this is a testament to EPA efforts to regulate these products. The final step is to monitor conditions to see if the impacts are as expected, with risk and benefit assessments refined as more information become available.

The Scientific Advisory Panel helped shape the EPA approach and to validate the scientific work from the beginning in the 1980s regarding potential risks of pollen drift (an ecological rather than worker issue) and the peer review in 1995 of the first risk assessment for a plant incorporated protectant (Bt potato) to current activities involving non-target species and insect resistance management. The purpose of this Panel is to advise on science with decisionmaking on pesticide approval for use residing with the Program Office.

Early ORD research efforts were very important for setting the early regulatory approach. While biotechnology research decreased in the early 1990s, the recent resurgence of research in this area is promising. This partnership, between regulatory program offices and researchers, is important to an effective program.

The role of science in regulatory decisionmaking was illustrated by two science issues: (1) Monarch butterfly exposure and risk from Bt crops, and (2) insect resistance. The initial risk assessment for Bt potato concluded that there were no significant effects to non-target butterflies or their caterpillar precursors; subsequently, a letter to *Nature* presented research results

implying that the pollen from altered corn would kill Monarch butterfly caterpillars. Industry and EPA immediately began research and scientific efforts (via USDA) that used science and the scientific process to demonstrate that no significant exposure occurs. However, the impact on regulation was to begin requiring the testing of a neutral relative of the target pest prior to granting commercial product approval and led to ongoing efforts to evaluate non-target organism testing for plant incorporated protectants.

As a second example, insect resistance management programs are only required for Bt crops. Initial concerns for protecting naturally-occurring Bt evolved into concerns regarding crop protection and the size of the refuge to plant. Answering these questions required exploration of the basic biological mechanisms of insects such as the frequency of resistant alleles in conjunction with modeling to predict years to resistance, with science improving methods to monitor for resistance. The impact on regulation was the first-time involvement of entomology researchers directly in the regulatory process.

Linking Strategic Environmental Monitoring to Risk Assessment of Biotechnology Products with Plant Incorporated Protectants

Dr. Robert Frederick, with NCEA, discussed monitoring in the context of risk assessment, which is at the heart of EPA's decisionmaking. NCEA focuses on how risk assessment is done, the principles behind it, methods used, and how to prepare for what is coming in the future.

Monitoring is very directed, so it is important to understand what to monitor in order to set up a successful program. Decisionmakers must understand what should be monitored, the reasons, how monitoring is to be carried out, and the purpose for the collected data as well as consequences and impacts of the decisions. All of these questions involve basic science.

Monitoring helps to improve the risk assessment process, provides information to decisionmakers, identifies important scientific developments, and helps to build public confidence. Yet, the public must understand that decisionmaking is not the endpoint and the decisionmakers must understand that they will not always have all of the information they would like.

The insect resistance management program for Bt cotton registration was cited as an example of a targeted, well-defined monitoring program. The initial program underwent reassessment that resulted in the inclusion of additional requirements for both Bt corn and cotton. This includes evaluating the efficacy of the refuge strategy to determine if impacts correlate with modeling results, determining if insect resistance is being delayed, and considering impacts on non-target species.

The National Research Council has conducted many workshops and produced reports on these issues, and has charged USDA and EPA to examine monitoring efforts in more depth. The potential use of genomics in these efforts is very exciting and will improve the risk assessment process in the future.

Challenges in monitoring include defining how much effort is sufficient, what to look for, how long to continue the monitoring, resources, and the ability to gain useful information in a

timeframe that is useful to EPA. Therefore, monitoring methodologies should be aimed at answering specific questions or concerns, must be appropriate and adequately targeted, consider the cost of monitoring compared to the value of the information gained, and must strategically define what information will be useful rather than collecting information solely for scientific curiosity.

Current research needs to support monitoring and risk assessment include baseline data for ecosystems and agro-ecosystems, fitness (defining and determinative characteristics), ecological effects such as non-target impacts and consequences following gene flow, environmental indicators, and mitigation technology. NCEA research is focusing on the agro-ecosystem condition, specifically in-field and near-field situations. Areas of particular interest include practical indicator(s) of change or impact, methods to address spatio-temporal issues, and methods to accommodate natural biological variability. NCEA is working with interagency panels and others to help develop this research program.

Remote Sensing for Bioengineered Crops

NRMRL scientist, Dr. John Glaser, discussed the potential applications of remote sensing to support compliance monitoring and development of insect resistance in bioengineered crops. Remote sensing is used in agriculture to monitor crop state, crop condition, and landscape characteristics. This information supports current applications in precision agriculture as well as nutrient and pesticide management. An example aerial image demonstrated how this capability can identify crop stress.

Since 1996, EPA has been involved with transgenic crops and their registration as pesticides. Each registration activity requires development by the seed producer of specified information on a variety of topics relating to the characteristics of the crops. New techniques are being developed to address information gaps identified from analysis of these data. ORD held a series of workshops in partnership with OPP to examine issues associated with pest simulation model design/validation, monitoring/detection, resistance estimation and refuge consideration, and remedial action strategies.

Bt corn is viewed as an environmental asset as a result of possible avoidance of pesticide applications that affect human health and ecosystems. Therefore, the ability to sustain this crop as long as possible is important. Risk management concerns for this crop include regulatory success, damage analysis, and manageability of risks with resistance management (the delay or prevention of adaptation) as a key consideration for sustainability.

Monitoring and surveillance are components of the Insect Resistance Management Plan for Bt corn. The purpose of resistance monitoring is to understand susceptibility at a baseline level, understand the changes in the frequency of resistant alleles, whether any dominant alleles develop into exposure, control failures, and what to do in response to failures. The strategy put forth by industry is to look at four distinct geographic areas of high Bt corn use and to look at specific insects. This is the basis of an aggressive, ongoing monitoring approach in use today. However, concerns have arisen as to whether the use of four limited geographic sections of the Bt corn crop can really provide for resistance detection if insect infestations begin as local phenomena. This in turn leads to consideration of remote sensing applications to aid in assessing

compliance, such as whether the grower is following requirements for refuges or as an early warning system by examining crop stress (an indirect approach in that pests infest stressed crops earlier than healthy crops).

Remote sensing sources include proximate sensing, aerial imagery, and satellite imagery (multispectral, hyperspectral). Multispectral imagery involves band analysis with sensor reception of specific bandwidths, while hyperspectral imagery focuses on distinct wavelengths. These imagery data in turn are correlated with field survey information (i.e., ground truthing to verify the image as received by the satellite), and then mapped for interpretation and analysis.

Use of remote sensing data from satellites requires understanding of the reflectance spectra since the reaction is different for different objects and their constituents. Vegetation includes a limited set of spectrally active compounds and their relative abundance can indicate vegetation condition; radiant energy from leaves changes remarkably between healthy, sick, and dead conditions. Vegetation structure also significantly influences reflectance. For example, leaf pigments, such as chlorophyll, respond to visible light, and there is a distinct wavelength shift from healthy green vegetation to stressed vegetation and to severely stressed (dying) vegetation with yellow and red pigments becoming more prevalent later in the crop cycle (plant die off). In addition, recent applications of satellite imagery have shown the ability to distinguish between conventional corn and Bt corn using one of the chlorophyll infrared wavelengths, raising questions as to whether the Bt corn is more photosynthetically prominent or more successful in using the incident light than conventional corn.

One potential application of this technique to refuge compliance monitoring is to acquire, ground truth, and map remote sensing data for specific geographic locations to determine if the required amount of refuge is actually in place. Candidate locations include areas of highest Bt corn crop usage such as parts of Minnesota, Pennsylvania, and Kansas.

Another potential application of remote sensing is to use infrared imagery and visible light imagery to detect pest infestation in a bioengineered crop. This approach uses indirect evidence to infer the development of resistance from differences in the spectral crop signature with the expectation that other types of crop impacts, such as herbivory, stress, and leaf senescence, can be distinguished one from the other.

Environmentally-Benign Polymeric Packaging from Renewable Resources

Associate Professor with the Colorado School of Mines, Dr. John Dorgan, discussed the applications of biotechnology to produce environmentally-benign plastics. Plastics production has roughly doubled every 10 years, relies on oil as a precursor, and results in a product that is predominantly for one time use and does not degrade in landfills. While there are many societal benefits of plastics (protect food, sanitary medical applications, secure packaging), there are also many sustainability issues given the geopolitical issues associated with oil, the production of greenhouse gases such as CO_2 from plastics production, and the ever decreasing landfill capacity worldwide.

Production of plastics and packaging materials (the single largest use of plastic) from biomass in a biorefinery may realize some advantages such as environmental benefits (less toxic or less

volume waste streams), national security benefits (reduced dependence on foreign petroleum), and rural economic growth (for raw materials). A biorefinery is analogous to a petroleum refinery and would produce fuels and materials based on raw biomass such as crops and agricultural byproducts.

Formidable technical challenges exist but advances in biotechnology and biochemical engineering are moving this goal closer to reality. There are several emerging success stories including polylactides (PLA) produced by DOW and a polymer produced by DuPont. Key to this is the ability to create a thermoplastic material that will break down in a landfill.

PLA has the lowest non-renewable energy content of many thermoplastic polymers. PLA is produced from corn using a combination of chemical and biological processes, including wet milling (to make corn starch and unrefined dextrose), fermentation (to generate lactic acid), and reactive distillation (to produce monomer and polymer). While PLA was first developed in 1932, mass production did not occur until a continuous process for high lactide purity, reactive distillation, was developed in the 1990s.

PLA is much like polystyrene and can go into many products. PLA can also be blended with other plastics to improve strength and the blend is 90 percent biodegradable. Barriers to acceptance include the need for test data for material properties and process evaluation as well as acceptance to support manufacturing switch over from oil-based chemical production techniques to combined biological and chemical techniques.

Current research efforts, many in partnership with EPA, are addressing the understanding of PLA properties and improving manufacturing quality control. Efforts to date have been able to reduce the QA/QC procedures to a single viscosity measurement to determine molecular weight, which is a key factor. This research also developed a tool to predict viscosity as manufacturing parameters, such as temperature, are changed; this can be used in planning for a change in a production process to substitute a biodegradable plastic by comparing the curve in a graph of viscosity versus sheer flow for their material with that of PLA.

Future developments in this area include more biotechnology-agrotechnology collaboration to produce new monomers to make biopolymers, development of nanocomposites to improve biopolymers, creation of bioplastic blends using starch, and the use of future farms as "macrobreweries" in which biorefineries evolve from a platform in plastics to fuels – the reverse of the historical progression in petroleum refining.

Science-Based Opportunities for Interagency Interactions Through the USDA Biotechnology Risk Assessment Research Grants Program

Dr. Deborah Hamernik, with the USDA, discussed a research grants program jointly administered and funded by USDA organizations including the Cooperative State Research, Education, and Extension Service, the Agricultural Research Service, and the United States Forest Service (also under the USDA) to assist Federal regulatory agencies in making science-based decisions about the safety of introducing genetically modified organisms into the environment. This Biotechnology Risk Assessment Research Grants Program was authorized in the 1990 Farm Bill and awards grants for extramural research, largely to land grant universities.

However, all public or private research or educational institutions in the United States are eligible to compete for these funds. While Federal research laboratories are eligible, this program awards only grants and not cooperative agreements.

Since 1992, approximately 100 grants totaling over $16 million have been awarded. From 1990 to 2002, a tax on biotechnology outlays funded this program. The 2002 Farm Bill increased this tax resulting in program funding of approximately $3 million annually, and set forth several key areas to address:

- Identify and develop appropriate management practices to minimize physical/biological risks associated with genetically engineered animals, plants, and micro-organisms. Examples include technology to reduce undesired spread of genetically engineered organisms, modeling of management strategies, developing effective genetic containment strategies, and identifying pests or pathogens that are developing resistance to transgenic resistance genes.

- Develop methods to monitor the dispersal of genetically-engineered animals, plants, and micro-organisms. Examples include strategies for large-scale deployment of genetically engineered organisms; the role of insects, birds, and other animals in distributing viable transgenic seeds; and survivability profiles and/or fitness studies.

- Further knowledge of the characteristics of rates and methods of gene transfer between engineered, wild, and agricultural organisms. Examples include potential for viral recombination, impacts of gene flow, and fate/stability of genes introduced by outcrossing into population of nontransgenic organisms.

- Conduct environmental assessment research to compare relative impacts of genetically modified organisms to other types of production systems. Examples include environmental effects associated with changes necessary for optimal agricultural management of transgenic crops, relative impacts of agricultural and forest management systems using transgenic versus nontransgenic organisms on ecosystem biodiversity, and whether introduction of transgenic organisms alters the impact of agriculture on the rural environment.

Other relevant areas of research include non-target effects and effects of genetically engineered plants with "stacked" resistance genes or genes that confer broad resistance to insects and diseases. Program efforts will also support conferences designed to bring together scientists, regulators, and other stakeholders to review science-based data on risk assessment and management of genetically modified organisms released to the environment. Areas not supported by this research program include clinical trials, commercial product development, product marketing strategies, food safety risk assessment, human/animal health effects, and social/economic issues.

This program posts Requests for Applications on the USDA website to solicit investigator-initiated research. Under this program, investigators design the projects and set the priorities. All proposals undergo peer review by a panel of scientific experts and Federal regulatory agencies, including the EPA, to help ensure that the funded research helps the regulatory process and agency research needs. Review criteria include scientific merit, relevance to risk assessment/risk management and Federal regulation of agricultural biotechnology, investigators, and institutional

capabilities. FY2002 research awards addressed a broad range of topics including gene flow, recombinant fungus in soil, risk assessment on the use of fungal insecticides, and large-scale ecological effects of herbicide tolerant crops on avian communities and reproduction. Abstracts and progress reports are available on the website.

Panel Discussion/Question and Answer

The speakers had an opportunity to participate in a brief panel discussion drawing on questions from the audience.

A brief question and answer period addressed a range of topics. One discussion area considered additional issues associated with transgenic crops. These included: (1) methods for grower education on transgenic crops including responsibilities of the companies providing the seed and collaboration with county extension agents; (2) responsibilities for monitoring refuges to ensure proper planting including third party telephone surveys, education programs, field surveys by grower representatives, and company policies regarding sales to growers who refuse to comply with refuge requirements; (3) the impacts of plant-manufactured enzymes on CO_2 production and in the overall chemical production process, noting that only the front end of manufacturing the catalyst (enzyme) is largely what changes; (4) consideration of land cost, irrigation, fertilizer, etc. in life cycle cost analysis for biopolymer production and use; (5) whether the energy cost is negative for plant production as it is for food, which might render biotechnology commercially nonviable, or whether commercial viability will be determined by the difference in the cost of manufacture and the price at which the product can be sold; and (6) the status of current efforts to determine if there are any soil changes resulting from transgenic crops and if the proteins of interest do breakdown in the soil.

Another discussion area addressed the USDA grant process and interagency interactions. There are often a large number of good research project proposals received in response to an RFA, but there may insufficient funding or the project may not fit within the RFA. A challenge is how to pass good projects along to the grant processes of other government agencies. Potential solutions included an interagency coordination effort initiated last fall by EPA for strategic planning and ongoing discussions of opportunities to co-fund STAR grants by EPA and USDA.

A third discussion area considered gene flow and future research directions for nontarget species. These included: (1) current research activities to understand baseline gene flow in order to measure changes and to address non-governmental organization concerns that zero gene flow should be the regulatory requirement; (2) use of genetic approaches to look at population structure (density, size) and connectivity with subpopulations; (3) existence of genetic banks developed by USDA for various crops to support gene flow studies; (4) questions about transgene movement to nonmodified crops or sexually compatible species, which is a particular concern in Europe where different crops are in much closer proximity than in the United States; (5) differences in emphasis (European and American) on avoiding genetic pollution or contamination versus prevention of gene flow with negative consequences; and (6) current laboratory and in-field testing and population evaluations for biotechnology products involving diverse nontarget species to determine positive and negative environmental impacts of these products.

Applying Nanotechnology to Solve Environmental Problems

Following opening remarks by Dr. Jack Puzak, Acting Director of NCEA, six speakers addressed the development and application of nanotechnologies. A panel discussion including an audience question and answer period followed the presentations.

Acting Director of NCEA, Dr. Jack Puzak, welcomed session attendees and provided an introduction to nanotechnology, which is the ability to work at the molecular level to create new structures. An interagency initiative, the National Nanotechnology Initiative, began in 2001 and doubled the government funding for nanotechnology research. EPA joined this effort in 2002 and also supports nanotechnology research through NCER's STAR grant and SBIR programs. Last year, NCER issued over $16 million in grants under the first call for nanotechnology research and is expected to issue another $5 million in grants later this year.

Nanotechnology may support revolutionary advances crossing all environmental areas from pollution prevention, sensors, and waste treatment to remediation. Yet these technologies may result in the release of new hazardous materials to the environment from their use or manufacture. Research efforts are beginning to address these issues as well as today's concerns and are enabling nanotechnology to be a vital new tool. Research planning efforts underway include the development of guidelines for nanotechnology research being held this week with 50 participants from academia, industry, and government.

Nanotechnology and the Environment: Keeping an Emerging Technology Green

Dr. Vicki Colvin, with the Center for Biological and Environmental Nanotechnology (CBEN), defined nanotechnology and addressed the state of its development as well as potential future applications. CBEN is one of six centers funded by the NSF for large groups of investigators. The mission is to create sustainable nanotechnologies that improve human health and the environment involving research in the basic sciences and engineering, partnerships with other government and academic organizations, and education. CBEN focuses on three research areas: biological engineering, nanostructures, and environmental engineering, including applications to water treatment.

Nanotechnology is one of the biggest research investments (over $1 billion) in the United States and is an emerging industry with many nanomaterials already in use today. Nanomaterials are small and are typically developed for structural perfection with large surface areas available for reaction, interaction, etc. The environmental applications and implications are only now beginning to be assessed.

A research goal of CBEN is to develop nanomaterials to help solve environmental issues. Research involves nanomaterials for environmental waste remediation and sensing as well as proactive investigations of the impact of nanomaterials in the environment. Key to this research are collaborative, cross-discipline communication and interaction.

A particular research focus is on membrane filter applications and enhanced performance. Municipal use of membrane technologies for high efficiency removal of specific contaminants has increased in the past 35 years. Such membranes offer cost-effective, high performance water

treatment, yet can be difficult to use given the pressures that must be generated for filtration. These efforts involve the construction of membranes with nanoparticles using alumoxanes (porous monoliths from alumoxanes) that have highly uniform pore size, reject material above 30 nanometers, and is a ceramic material useful in highly corrosive waste streams.

Existing challenges are the high pressures required for performance (>100 psi), fouling from pore blocking, and ability of the filter to remediate and remove contaminants. Changes in membrane architecture, by developing membranes with much more open structures, result in lower pressures required for performance; in addition, reactive components can be included in such structures to remediate the water stream as well.

The large surface areas found in nanoparticles provide large capacities for sorbing particles, which led to the concept of generating materials that attract contaminants and effectively remove them from solution. One example is the use of a magnetic removal process in which a nanoparticle core and surface are engineered for different reasons – the core to support the material that in turn supports the surface chemistry mode of action.

New technologies include both benefits and risks. Several past examples were presented of technologies that achieved specific results, yet resulted in undesirable, unintended consequences; for example, use of pesticides to improve crop yields, yet are toxic to animals. Environmental costs are expensive, are paid over the long-term, and can be social deal-breakers for new technologies with the decisions on new technology use residing with the policymakers. The economic realities of funding a new material without understanding the long-term liability is significant and can include limited markets, recalls, and lawsuits.

Environmental and health risks associated with nanomaterial use are of concern recognizing that it may not be possible to conduct a risk assessment on every nanomaterial developed. Exposure issues include questions on the quantities involved, the effects from ingestion, and fate and transport including how engineered nanoparticles may be naturally concentrated and degraded. These are areas of CBEN research as well as bioaccumulation. Very little is known about the toxicity of engineered nanomaterials, and many core toxicity issues may be different for these types of very small particles developed to be perfect. The role of public policy will be to help the public determine if these are safe.

The Future of the National Nanotechnology Initiative

NSF Senior Advisor, Dr. Mike Roco, discussed the development and implications of nanotechnology as well as the creation and implementation of the National Nanotechnology Initiative (NNI). Nanotechnology has not left any major field of science untouched worldwide and involves increasing government and private sector investment. This is a promising technology that is still in the exploratory phase with much emphasis on catalysts and computer components.

The definition of nanotechnology varies around the world. In the United States, nanotechnology involves work at the atomic, molecular, and supramolecular levels (scale measured in nanometers) in order to understand and create materials, devices, and systems with fundamentally new properties and functions because of their small structure. Areas of specific

interest include miniaturization, novel properties/phenomena/processes, and efficiencies in manufacturing. Broad societal implications of this technology encompass improved understanding of life and nature, new products, sustainable development, and improved healthcare.

The history of nanotechnology begins over 1,000 years ago with the accidental discovery of carbon black. However, most of the technology development effort has occurred since 1990 with isolated applications involving catalysts and composites. The first generation involved passive nanostructures and this is evolving into a second generation of active nanostructures. This is anticipated to be followed by a third generation of three-dimensional nanosystems with heterogeneous nanocomponents, diverse assembling techniques, and nanoscale networking.

The NNI involves many Federal departments and independent agencies, with matching funds or other investments by states beginning last year. NNI prepared and continues to prepare many reports and evaluations of nanotechnology, its development, its potential future, and societal implications. These documents as well as a review of NNI are available on the at www.nano.gov. NNI also conducts a number of national and international workshops on various application areas and research directions

Key investment strategies are to focus on fundamental research and transition to technical innovation, addressing broad societal aspects, long-term vision (over next 20 years) of the evolution of this technology, and preparing the nanotechnology workforce. All of these initiatives involve partnerships for interdisciplinary and interagency collaboration. Nanotechnology funding across Federal agencies has increased from $270 million in 2000 to almost $600 million in 2002 with Federal agencies committing more in the future than NNI originally anticipated. The number of research proposals is increasing faster than funding, and the research is looking to more complex systems and applications.

Nanotechnology produces revolutionary technologies, products, and services. Growth areas include materials, chemicals (catalysts), pharmaceuticals, and electronics. Emerging areas include nanomedicine, energy conversion and storage, agriculture/food systems, molecular architectures for manufacturing, realistic multiphenomena and multiscale simulations, and environmental implications.

A September 2000 report noted the need to make social, ethical, and economic research studies a priority to be able to communicate with the public and address unexpected consequences as well as to develop a basic reference for interaction with the public. This in turn will support the ability to take faster advantage of the benefits. At the international level, there is much attention being given to potential dangers and this is well-funded and vocal. Lessons learned from interacting with these organizations are the need to communicate what research has already been conducted and its findings to address their potential issues of concern, to be conscientious in addressing issues of all people, to be aware of the diverse public concerns, and to address the serious issues. This points to the need for increased investment in societal, educational, and environmental implications, and NNI is currently funding a number of research projects in these areas.

Nanotechnology holds major, positive implications for the environment. For example, nanotechnology provides a means for sustainable development through "exact" manufacturing and methods to address current health and environmental issues using nanoscale sensors.

Key issues for 2003 and beyond are the need for coherent five to 10 year programs (long-term vision and investment), horizontal rather than vertical science and technology development to spread the technology into different fields, and a research and development vision founded in those who will make the products.

Nanostructured Porous Silicon and Luminescent Polysiloles as Chemical Sensors for Carcinogenic Chromium (VI) and Arsenic (V)

Dr. William Trogler, with the University of California-San Diego, discussed nanotechnology applications of polysiloles to detect pollutants in aquatic systems. Polysiloles possess a chain of silicon atoms surrounded by phenyl constituents with a structure resembling a silicon wire with a phenyl coating. Polysiloles are electroluminescent materials involving fluorescence rather than phosphorescence. Chemicals that come into contact with the reactive silicon core change the luminescence, which can be detected.

Polysiloles are easy to produce in a two step process (as compared to other types of polymers that require a 12 step process). The resulting polymer is photoluminescent, soluble in organic solvents, and stable in air and water. These serve as excellent sensors for TNT with a detection limit of approximately 1 part per trillion. The mechanism of detection is passive.

A catalytic dehydrocoupling method is used to produce polysiloles. Potential applications of this redox coupling technique are to detect heavy metals such as hexavalent chromium (Cr+6) and arsenic. Chromium analysis is commonly required for diverse EPA regulatory compliance programs, and often relies on total chromium analyses when hexavalent chromium is the toxic species of interest. Arsenate, the mobile form of arsenic in aerated water, is another toxic species of even greater concern. Regulatory limits for both of these species are in the parts per billion range. Inexpensive nanosensing elements could support wide application from remote monitoring to process control to replace reliance on grab sampling followed by laboratory analysis.

The luminescent polysiloles require treatment with amines in order to detect chromium. Early research did not achieve the desired detection limit. Additional difficulties included undesirable physical property changes that occur when adding water to an organometallic, which creates colloids. By changing the technique from a polymer sensor to a nanoparticle sensor, the required EPA detection limit could be met for hexavalent chromium. Efforts are underway to improve the detection capability for arsenic.

These results led to consideration of organometallic colloids as sensors—entitled quantum dot sensing. The colloids scatter light in the visible range, but are also very luminescent. This is a property that may warrant further exploration.

An advantage of nanotechnology is the ease of making modifications to molecules. Creation of the aminosilole nanoparticles for hexavalent chromium detection improved selectivity for the

chromium even further because the molecular surface was loaded with more functionality. Thus, this nanoparticle technology has the potential for use as a field test because changes in luminosity that correlate to different hexavalent chromium concentrations are visible to the human eye.

Another example involved the use of a biomemitic approach to nanocoat a nanoparticle with silica, which smoothed the surface of the material.

Nanoscale Biopolymers for Decontamination and Recycling of Heavy Metals

Dr. Wilfred Chen, with the University of California-Riverside, discussed the design, production, and application of biopolymers to remove heavy metals from aqueous solutions and environmental media. A challenge faced by industry is that conventional technologies can significantly reduce heavy metal concentrations in wastestreams, but secondary processes (such as metal chelating polymers that are produced with toxic solvents) are often required to achieve regulatory standards. The polymers are then removed by an ultrafiltration membrane, which is energy intensive and subject to clogging. A potential solution is to develop metal-binding materials that can be recovered by environmental stimuli.

Metal chelating biopolymers are based on biological building blocks such as amino acids. They offer good control over composition and properties because they can be pre-programmed within a DNA template, do not require chemical synthesis, high quantities can be produced economically by bacteria, and are environmentally friendly. An elastin biopolymer, for example, is very simple with five peptides being the most frequently repeating units, is structurally similar to the repeating elastometric peptide sequence of the mammalian protein elastin, and undergoes a reversible phase transition from water soluble forms into aggregates as temperature increases. By creating both an elastin domain and a metal binding domain in the same molecule, the properties can be controlled and the affinity to different metal species can be fine tuned. Temperature is then used to remove captured metals from the polymer protein to regenerate the material for reuse in metal removal.

Production involves preparation of a DNA template for the desired composition, then adding the template to a bacterial cell, which in turn will generate the biopolymer through fermentation. This process enables precise control of the link and composition as well as the metal binding domain to produce customized polymers for the properties of interest. The desired transition temperature can be obtained by controlling the length of the polymer and the metal binding domain can be customized for specificity and capacity.

The transition property can be measured by measuring turbidity changes with temperature. It is possible to achieve a specific transition temperature within the range of 20 to 40 degrees Centigrade by controlling the chain length and salt concentration. Regeneration is quite rapid, and the transition temperature is sensitive to ionic strength.

Experimental results using cadmium demonstrated that biopolymers do sequester metals from solution. Research also addressed repeated the regeneration process and determined that the binding capability remained fairly constant over four regeneration cycles (using acid for

regeneration). Current research involves injection of a biopolymer solution into cadmium-contaminated soils and preliminary results indicate significant levels of cadmium removal.

First generation biopolymers as described above serve as simple metal binding domains. Nature offers bacteria and other micro-organisms that can concentrate heavy metals. For example, bacteria can produce an enzyme to change metallic mercury to another form that is much more volatile yet a high affinity is required to respond to trace amounts of mercury. Research activities are investigating whether biopolymers with such properties can be produced and purified. Results indicate fairly consistent mercury binding capability across a pH range of 4 to 9, when most other binding proteins typically have a much narrower range. In addition, the research demonstrates that the binding was very specific to mercury even in conditions where zinc and cadmium were also present.

The ultimate goal is to develop an array of such metalloregulatory proteins to address many heavy metals including arsenic and chromium. By tuning the elastin composition, differential precipitation and recovery will be accomplished. It may be possible to design different transition temperatures for different metals enabling differential metal removal coupled with protein recovery.

Molecular-Dynamics Simulation of Forces Between Colloidal Nanoparticles

Dr. Kristen Fichthorn, with Pennsylvania State University, discussed new findings in molecular dynamics from simulation of forces between colloidal nanoparticles, which are potential building blocks for materials such as catalysts as well as optical, structural, and electronic materials. With nanoparticles, changing a few atoms can change the action. This property can be used to create specific patterns such as a hexagon or a square, yet it is difficult to assemble nanoparticles into specific shapes or to disperse them, as there is a tendency toward aggregation in solution. Dispersants added to solutions to prevent aggregation have been found to take up a much larger molecular volume than found in conventional colloids. Nanoparticle behavior, and the forces involved, is typically extrapolated from that of conventional colloids of microparticles; however, current research findings indicate that there is a difference.

Molecular dynamics involves the following colloidal forces: van der Waals and electrostatic forces (between micron-sized particles), solvation forces derived from ordering of molecules in a solvent (which may be much stronger than previously thought), and depletion forces (entropic) that occur in a mixture of different sizes of objects in a colloid. A major question to address through theoretical and experimental research is how these forces work for colloidal nanoparticles.

Electrodynamic simulations model every molecule in a suspension and consider the force between two nanoparticles separated by a specified distance. The simulation enables understanding of the spatial location of each molecule to both better understand the forces and to understand experimental data. EPA funding is supporting a large-scale parallel molecular dynamics simulation in a Beowulf Cluster Cruncher using a Lennard-Jones liquid and both solvophilic and solvophobic nanoparticles. Since molecular forces are sensitive to the shape and size of the colloid, the research examines differences in behavior for various sized spheres as well as cube-shaped nanoparticles. Two key questions are whether the van der Waals forces for

nanoparticles scale according to a specific formula relating to separation distance, and the role that the solvent molecules have for colloidal nanoparticles.

Simulation findings indicate that current theories do not accurately describe van der Waals forces for small particles. Findings also indicate that the solvation forces are comparable to van der Waals forces and may have a significant impact in modeling as well as in understanding nanoparticle colloids. Shape appears to have a significant influence on the solvation forces; for example, solvation forces for nanoparticle cubes were estimated to be significantly higher than for the nanoparticle spheres and were also stronger than the van der Waals forces. Simulation results also indicated that solvophobic forces are much weaker than the solvophilic forces, the solvent-solid interaction is greater than the solvent-solvent interaction, and the solid-solid interaction is strongest.

Conclusions from simulation results to date are that current theories do not accurately describe forces for small nanoparticles, solvation forces are important for colloidal nanoparticles, and solvation forces are strongly dependent on particle size, shape, surface roughness, and particle-solvent interactions.

Development of Nanocrystalline Zeolite Materials as Environmental Catalysts: From Environmentally Benign Synthesis to Emission Abatement

Dr. Vicki Grassian, with the University of Iowa, discussed the manufacture of nanocrystal zeolite materials, their properties, and potential applications. Environmental catalysis uses a catalyst to make molecules in an environmentally benign manner. This minimizes the generation of hazardous/toxic materials and their management, promotes waste minimization/reuse, and supports pollution control. Of particular interest is the controlled synthesis and formation of zeolite nanoparticles and nanostructures for catalysis and sensor technology.

Zeolites are well-known crystalline, aluminum silicate, nanoporous materials. Zeolite particle sizes and aggregates are typically about 1000 nanometers in diameter and their nanoproperties derive in part from the size of the internal cavities. There are both natural and synthetic zeolites available with uses such as shape-selective catalysts, separation (through size exclusion), adsorbent (drying agent), sensors, and ion exchange. Commercially available zeolites are crystal aggregates, while commercial synthesis generates large particles.

Zeolite preparation via controlled synthesis (via hydrothermal or confined space methods) results in smaller particle sizes with minimal aggregation. The hydrothermal method is the preferred method for this research effort because of the ease of production and the shorter development time. Changing the pH and temperature conditions enabled production of much smaller particle sizes (to 40 nanometers) with additional modifications further reducing particle size to 10 nanometers. Techniques used to characterize the resulting particles are microscopy, spectroscopy, and chemical and physical methods. Advantages of nanometer-sized zeolites include: (1) more uniform and controlled size and site distribution, (2) ability to form dense, uniform nanostructures (films), (3) optical transparency, (4) increased external surface area, and (5) ease of adsorption and desorption.

The nanostructures of interest in this research program are the use of zeolite nanoparticles in thin films and coatings. Preparation of thin films via hydrosol evaporation resulted in significantly increased optical transmission and a smoother film surface than that achieved with commercial zeolite particles. Interest in optically transparent films includes potential applications for partial hydrocarbon oxidation, an important chemical industry process. A major problem encountered in this process is selectivity because the desired end products are more easily oxidized; therefore, conversions are kept low. This technology may enable the conversions to be increased. Experimental results found that as the zeolite layer became thicker, a specific chemical conversion (p-xylene to p-tolulaldehyde) decreased. Oxidation reactions of cyclohexane also indicate greater conversion with higher quality optical materials.

Results of this research to date demonstrate that controlled synthesis of zeolites yields smaller particles and that particle size can be tuned using reaction conditions. In addition, nanocrystalline zeolites can be used to produce high quality nanostructure materials (e.g., thin films and coatings) that are better than commercially available materials and have different physicochemical properties. Future research efforts will focus on obtaining smaller particle sizes and exploring applications in environmental catalysis.

Panel Discussion/Questions and Answers

The speakers had an opportunity to participate in a brief panel discussion drawing on questions from the audience.

A brief question and answer period addressed a range of topics. One discussion area considered identification of the most important nanotechnology application. These included: (1) diverse potential applications of nanotechnology with particular emphasis on use as catalysts with high efficiency for one product and broad environmental benefits through minimal generation of byproducts and waste; (2) potential future emphasis on both selectivity and efficiency; (3) use in sensor technology; (4) ability to support real-time calibration for field applications; (5) integrating processes into a single material; (6) use of biomass for catalysts; (7) aid in understanding boundary lines; and (8) the importance of understanding the fundamental aspects nano-sized structures, how they are built, and how they work in order to develop applications.

Another discussion area considered research questions, approaches, and future directions. These included: (1) better understanding of nanoprocesses with an example being how PCB sorption in sediments occurs; (2) understanding the physics of nanoparticles and how they assemble, to facilitate future exploitation of such processes in combined natural/manmade systems; (3) differences in research approaches between countries with Japan focused on a single application, the United States having a broader approach, and Europe more imaginative; (4) the need for international collaboration and information exchange; (5) integration of existing research such as integration of nanofiltration with nanosensors for biofouling; (6) more inter-disciplinary emphasis on future grant solicitations; (7) determination of research emphasis such as pollution prevention or remediation as the technologies are different; (8) importance of green manufacturing for nanomaterials; (9) consideration of research center opportunities and approaches (e.g., multidisciplinary and multi-investigator groups) to overcome challenges faced when only a few research programs attempt to combine expertise; (10) having the theoretical

research occur in tandem with experimental research; and (11) the need for funding mechanisms in a period of decreasing grant budgets.

Appendix A: Meeting Agenda

EPA 2003 Science Forum: Partnering to Protect Human Health and the Environment

May 5-7, 2003, Washington, DC

FINAL AGENDA

Day 1 - Monday, May 5, 2003

Note: The poster and exhibit rooms will be open from 8:00 AM to 7:00 PM.

7:00 AM - 8:45 AM	*Registration* ***(Atrium Hall Lobby)***
	Plenary Session (*Amphitheatre*)
9:00 AM - 9:20 AM	Plenary (Christine Todd Whitman, EPA Administrator)
9:20 AM - 9:40 AM	Plenary (Dr. Paul Gilman, Science Advisor, EPA)
9:40 AM - 10:00 AM	Plenary (Mr. Jimmy Palmer, Regional Administrator, EPA Region 4)
10:00 AM - 10:30 AM	Plenary (Mr. James Connaughton, Chairman, White House Council on Environmental Quality)
10:30 AM - 11:00 AM	Overview (Dr. Kevin Teichman, Director, Office of Science Policy, ORD, EPA)
11:00 AM - 1:00 PM	*Lunch*
1:00 PM - 1:30 PM	Plenary (**Homeland Security** – Dr. John Vitko, Director for the Biological and Chemical Countermeasures Portfolio, Department of Homeland Security)
1:30 PM - 2:15 PM	Plenary (**Moving Science Into Action** - Mr. William G. Ross, Jr., Secretary, North Carolina Department of Environment and Natural Resources; Mr. James Ransom, Director, Haudenosaunee Environmental Task Force, Mohawk Nation of Akwesasne)
2:15 PM - 2:45 PM	Plenary (**Year of Water** - Dr. Sylvia Earle, Marine Biologist and Explorer-in-Residence, National Geographic Society)
2:45 PM - 3:15 PM	Plenary (**Emerging Technologies** - Mr. David Rejeski, Director, Foresight and Governance Project, Woodrow Wilson International Center for Scholars)
3:15 PM - 3:45 PM	*Break*
3:45 PM - 7:00 PM	Poster Presentations/Reception/Awards Ceremony **(*Atrium Hall*)**

Day 2 - Tuesday, May 6, 2003

Note: The poster and exhibit rooms will be open from 8:00 AM to 5:00 PM.

7:00 AM - 8:30 AM *Registration* ***(Atrium Hall Lobby)***

Plenary Session (*Amphitheatre*)

8:30 AM - 9:00 AM Plenary (Recap of Day 1 and Open of Day 2)

9:00 AM - 9:30 AM Plenary (Ms. Linda Fisher, EPA Deputy Administrator)

Moving Science Into Action *(Hemisphere A)*

9:30 AM - 11:00 AM

Regional Vulnerability Assessment (ReVA): Improving Environmental Decision-Making Through Client Partnerships

Moderator: Dr. Betsy Smith, NERL, ORD, EPA
ReVA's Client Partnerships: Improving Environmental Decision-Making Through Applied Research – Dr. Betsy Smith, NERL, ORD, EPA
ReVA's Web-Based Application: A Tool for Regional, State, and Local Decision-Makers – Dr. Michael O'Connell, Waratah Corporation
The Sustainable Environmental for Quality of Life (SEQL) Program: A Partnership Between EPA ORD and OAQPS, and State and Local Governments – Ms. Rebecca Yarbrough, Centralina Council of Governments
ReVA's Partnership with Maryland DNR: Opportunities to Optimize the Future – Mr. William Jenkins, Maryland DNR

Break

11:30 AM - 1:00 PM

Partnership with State and Local Government

Moderator: Mr. Gilberto Alvarez, EPA Region 5
Michigan Environmental Science Board and Protecting Children's Health – Mr. Keith Harrison, Michigan Environmental Science Board
Integrated Environmental Planning Across Two States, 15 Counties, and 36 Municipalities: Do You Believe in Miracles? – Dr. Linda Rimer, EPA Region 4
Delta Cross Channel Gate Operation on Water Quality and Migration of Juvenile and Adult Salmon in Northern California – Dr. Bruce Herbold, EPA Region 9

Lunch

2:00 PM - 3:30 PM

Advancing Science Through Environmental Monitoring and Assessment Program (EMAP) Partnerships

Moderator: Dr. Michael McDonald, Director of EMAP
EMAP-West: Introduction – Dr. Roger Blair, NHEERL, ORD, EPA
The EMAP Western Pilot in Region 8 – Mr. Karl Hermann, EPA Region 8
Perspective from the State of California – Mr. James Harrington, California Department of Fish and Game
EMAP Tribal Perspectives – Mr. Jefferson Davis, Nez Perce Tribe

Break

Day 2 - Tuesday, May 6, 2003 (continued)

Moving Science Into Action (continued) *(Hemisphere A)*

Advancing Science Through Environmental Monitoring and Assessment Program (EMAP) Partnerships (continued)

4:00 PM - 5:30 PM

National Coastal Assessment: Past, Present, and Future – Dr. Kevin Summers, NHEERL, ORD, EPA

The Interactions of EMAP and SCCWRP: Help in the Past, Necessity for the Future – Dr. Stephen Weisberg, Southern California Water Research Program

The Role of the National Coastal Assessment in Developing a Continuing South Carolina Estuarine Monitoring Program – Dr. Robert Van Dolah, South Carolina DNR

The Application of EMAP and REMAP in the EPA Regions – Ms. Darvene Adams, EPA Region 2

Questions and Answers

Day 2 - Tuesday, May 6, 2003 (continued)

Emerging Technologies *(Amphitheatre)*

9:30 AM - 11:00 AM

Applying Computational Toxicology to Solving Environmental Problems

Computational Toxicology: Bolstering the Environmental Protection Agency's Mission - Dr. William Farland, ORD, EPA
Toxicogenomic Predictive Modeling – Dr. Donna Mendrick, Gene Logic, Inc.
EPA's Research Program on Computational Toxicology – Dr. Lawrence Reiter, NHEERL, ORD, EPA
Novel Informatics and Pattern Recognition Tools for Computational Toxicology – Dr. William Welsh, Robert Wood Johnson Medical School and The UMDNJ Informatics Institute
Computational Toxicology and Genomics: The Next Wave of Drinking Water Research – Dr. Douglas Wolf, NHEERL, ORD, EPA

Break

11:30 AM - 1:00 PM

Applying Computational Toxicology to Solving Environmental Problems (continued)

The Genomic Path From Exposure to Effects in Aquatic Ecosystems – Dr. David Lattier, NERL, ORD, EPA
Structure Activity Tools for Assessing Pesticides and Toxic Substances – Past, Present, and Future – Mr. Joseph Merenda, Jr., OSCP, OPPTS, EPA
NIEHS Toxicogenomics Centers: Model for Partnerships – Dr. Bennett Van Houten, NIEHS
Panel Discussion / Questions and Answers

Lunch

2:00 PM - 3:30 PM

Innovation to Advance the Detection of Threats and Optimize Environmental Decision Making

Information Technology Science: Bolstering the Environmental Protection Agency's Mission – Dr. Gary Foley, NERL, ORD, EPA
Meeting National Environmental Goals: Coordinated Federal IT Solutions – Dr. David Nelson, White House National Coordination Office for Information Technology Research and Development
Application of Advanced Information Technology to Promote, Educate, and Address Environmental Concerns – Ms. E. Ramona Trovato, OEI, EPA
Monitoring Stressors to Human and Ecosystem Health from Space – Mr. David Williams, ORD, EPA and Mr. Jim Szykman, OAQPS, EPA
ASPECT: Protecting Americans Through Rapid Detection of Atmospheric Contaminants – Dr. Mark Thomas, EPA Region 7

Break

4:00 PM - 5:30 PM

Innovation to Advance the Detection of Threats and Optimize Environmental Decision Making (continued)

Simulation and Visualization of the Smoke/Dust Plume from the World Trade Center – Dr. Steven Perry, NERL, ORD, EPA
Real-Time Monitoring and Communication of Air Quality – Mr. Timothy Hanley, OAR, EPA
Panel Discussion / Questions and Answers

Day 2 - Tuesday, May 6, 2003 (continued)

Year of Water: 30 Years of Progress Through Partnerships *(Hemisphere B)*

9:30 AM - 11:00 AM

Waterborne Disease in the U.S.

Introduction - Dr. Fred Hauchman, NHEERL, ORD, EPA
EPA Studies of Endemic and Epidemic Waterborne Diseases – Dr. Rebecca Calderon, NHEERL, ORD, EPA
Using Randomized Trials to Study Waterborne Pathogens Among Susceptible Populations – Dr. Jack Colford, University of California, Berkley
Maintaining Microbiological Quality of Drinking Water in the Distribution System – Dr. Mark LeChevallier, American Water

Break

11:30 AM - 1:00 PM

Mississippi River Basin Hypoxia

Moderator: Ms. Katie Flahive, OWOW, OW, EPA
The Science of Hypoxia – Dr. David Flemer, OST, OW, EPA
Mississippi Basin Implementation – Ms. Katie Flahive, OWOW, OW, EPA

Lunch

2:00 PM - 3:30 PM

The Millennium Challenge: EPA's Response to Invasive Species

Moderators: Mr. Michael Slimak, NCEA, ORD, EPA and Ms. Marilyn Katz, OWOW, OW, EPA
The Office of Water Perspective – Mr. G. Tracy Mehan, III, OW, EPA
Research in Support of the Coast Guard's Program to Prevent the Introduction of Nonindigenous Species by Ships – Dr. Richard Everett, U.S. Coast Guard
International Efforts to Address the Transfer of Invasive Species Via Ballast Water – Ms. Kathy Hurld, OWOW, OW, EPA
A "Shocking" Solution to Controlling the Spread of Asian Carp into the Great Lakes – Dr. Marc Tuchman, GLNPO, EPA
Environmental Perspectives on Invasive Species Control – Ms. Jacqueline Savitz, Pollution Program, Oceana
Invasive Species and Pesticide Control Programs – Mr. Daniel Rosenblatt, OPP, OPPTS, EPA

Break

4:00 PM - 5:30 PM

Social Science and Resistance to Water Fluoridation

Moderator: Ms. Roberta Baskin, Public Affairs TV (NOW with Bill Moyers)
Fluoridation: An Undefendable Practice – Dr. Paul Connett, St. Lawrence University
TBA

Day 2 - Tuesday, May 6, 2003 (continued)

Homeland Security *(Oceanic AB)*

9:30 AM - 11:00 AM

Anthrax: Response and Research

Anthrax Response and Recovery: Applied Science & Technology, and Future Needs – Keynote: Mr. Thomas Voltaggio, EPA Region 3
EPA's Homeland Security Research Program – Mr. E. Timothy Oppelt, ORD, EPA
Secondary Aerosolization of Viable *Bacillus Anthracis* Spores in an Office Environment – Dr. Chris Weis, NEIC, EPA

Break

11:30 AM - 1:00 PM

Anthrax: Detection, Sampling and Analysis

Environmental Sampling of Bio-Aerosols – Mr. Mark Durno, EPA Region 5 and Mr. Ken Martinez, NIOSH

Lunch

2:00 PM - 3:30 PM

Anthrax: Fumigation and Re-occupancy

Fumigating Anthrax-Contaminated Sites: Building on Experience – Dr. Dorothy Canter, OSWER, EPA
Clearance Determinations: Judging Remediation Success and Readiness for Re-occupancy – Mr. Jack Kelly, EPA Region 3 and Mr. Matt Gillen, NIOSH

Break

4:00 PM - 5:30 PM

Anthrax: Decontamination Technologies

The Hunt for Anthrax Decontamination Chemicals – Mr. Jeff Kempter, OPP, OPPTS, EPA and Mr. Jeff Heimerman, TIO, OSWER, EPA
Laboratory Support for Evaluating Decontamination Technologies – Ms. Rebecca Schultheiss, OPP, OPPTS, EPA
Efficacy Testing Science Issues and Follow-Up Research – Dr. Stephen Tomasino, OPP, OPPTS, EPA

Day 3 - Wednesday, May 7, 2003

Moving Science Into Action *(Hemisphere B)*

8:30 AM - 10:00 AM

Working with Tribes: Cultural Values and Tribal Lifeways Inform Health Assessments

Moderator: Mr. Thomas Baugh, EPA Region 4
Tribal Partnerships in Pesticide Management to Protect Human Health – Ms. Sarah Ryan, Big Valley Rancheria
Establishing Self-Sufficiency in Alaska Native Communities to Minimize Exposure to Environmental Contaminants – Ms. June Gologergen-Martin, Alaska Community Action on Toxics
Bioaccumulative Toxics in Native American Shellfish – Ms. Jamie Donatuto and Mr. Larry Campbell, Swinomish Indian Tribal Community

Break

10:30 AM - 12:00 PM

Moving Science Into Action – Step One: Get the Data!

Moderator: Ms. Pamela Russell, OEI, EPA
Introductory Remarks – Mr. Mike Flynn, OEI, EPA
Uses of Toxics Release Inventory Data – Ms. Gail Froiman, OEI, EPA
Integration of State and County Stream Monitoring Programs: A Maryland Case Study – Mr. Wayne Davis, OEI, EPA and Dr. Ron Klauda, Maryland DNR and Mr. Keith Van Ness, Montgomery County Department of the Environment
Effects of Urban Growth on Fish Assemblages in a North Carolina Metropolitan Area, 1970-2000 – Dr. Jonathan Kennen, USGS and Ms. Ming Chang, OEI, EPA
Dynamic Choropleth (DC) Maps – Dr. William P. Smith, OEI, EPA

Lunch

1:30 PM - 3:00 PM

Emerging Innovations in Regional Ecosystem Protection

Regional Ecosystem Protection: What Does It Offer Our Future? – Mr. John Perrecone, EPA Region 5 and Mr. Doug Norton, OW, EPA
Use of Geospatial Tools to Identify High Quality Midwest Ecosystems – Dr. Mary White, EPA Region 5 and Mr. John Perrecone, EPA Region 5
Synoptic Model to Rank Wetland Ecosystems for 404 Permitting: An Application of Regional Critical Ecosystems Protection – Ms. Brenda Groskinsky, EPA Region 7
Southeastern Ecological Framework's GeoBook – Software for Mapping Partnerships and Ecosystem Protection – Dr. John Richardson, EPA Region 4
The Mid-Atlantic Highlands Action Program: Transforming the Legacy – Mr. Tom DeMoss, Mr. Randy Pomponio, and Ms. Jennifer Newland, Canaan Valley Institute

Day 3 - Wednesday, May 7, 2003 (continued)

Moving Science Into Action (continued) *(Hemisphere B)*

Break

3:30 PM - 5:00 PM

Site Characterization and Decision Analysis of Contaminated Sediments

Introduction – Dr. John Bing-Canar, EPA Region 5
Introduction to Concepts and Tools – Mr. Brian Cooper, EPA Region 5
Initial Sample Design – Dr. John Kern, Kern Statistical Services, Inc.
Spatial Estimation – Dr. John Bing-Canar, EPA Region 5
Decision Analysis – Mr. Charles Roth, EPA Region 5

Day 3 - Wednesday, May 7, 2003 (continued)

Emerging Technologies *(Hemisphere A)*

8:30 AM - 10:00 AM

Applying Biotechnology to Achieve Sustainable Environmental Systems

Introductions and Welcome – Dr. Hugh McKinnon, NRMRL, ORD, EPA
Molecular Farming for Sustainable Chemistry – Dr. Barry Marrs, Fraunhofer Center for Molecular Biotechnology
EPA Biotechnology Program Overview – Dr. Lawrence Reiter, NHEERL, ORD, EPA
Regulatory Perspective on Bio-Engineered Crops – Dr. Janet Andersen, OPP, OPPTS, EPA
Linking Strategic Environmental Monitoring to Risk Assessment of Biotechnology Products with Plant Incorporated Protectants (PIPs) – Dr. Robert Frederick, NCEA, ORD, EPA

Break

10:30 AM - 12:00 PM

Applying Biotechnology to Achieve Sustainable Environmental Systems cont.

Remote Sensing for Bio-Engineered Crops – Dr. John Glaser, NRMRL, ORD, EPA
Environmentally Benign Polymeric Packaging from Renewable Resources – Dr. John Dorgan, Colorado School of Mines
Science-Based Opportunities for Inter-Agency Interactions through the USDA Biotechnology Risk Assessment Research Grants Program – Dr. Deborah Hamernik, US Department of Agriculture
Panel Discussion / Questions and Answers

Lunch

1:30 PM - 3:00 PM

Applying Nanotechnology to Solve Environmental Problems

Introductions and Welcome – Dr. Jack Puzak, NCEA, ORD, EPA
Nanotechnology and the Environment: Keeping an Emerging Technology Green– Dr. Vicki Colvin, Center for Biological and Environmental Nanotechnology, Rice University
The Future of the National Nanotechnology Initiative – Dr. Mike Roco, National Science Foundation
Nanostructured Porous Silicon and Luminescent Polysiloles as Chemical Sensors for Carcinogenic Chromium (VI) and Arsenic (V) – Dr. William Trogler, University of California, San Diego

Break

3:30 PM - 5:00 PM

Applying Nanotechnology to Solve Environmental Problems cont.

Nanoscale Biopolymers for Decontamination and Recycling of Heavy Metals– Dr. Wilfred Chen, University of California, Riverside
Molecular-Dynamics Simulation of Forces Between Colloidal Nanoparticles – Dr. Kristen Fichthorn, Pennsylvania State University
Development of Nanocrystalline Zeolite Materials as Environmental Catalysis: From Environmentally Benign Synthesis to Emission Abatement – Dr. Vicki Grassian, University of Iowa
Panel Discussion / Questions and Answers

Day 3 - Wednesday, May 7, 2003 (continued)

Year of Water: 30 Years of Progress Through Partnerships *(Oceanic AB)*

8:30 AM - 10:00 AM

Development of Biological Indices for Coral Ecosystem Assessments

Moderator: Mr. Kennard Potts, OWOW, OW, EPA
Assessing the Consequences of Global Change for Coral Reef Ecosystems – Dr. Jordan West, NCEA, ORD, EPA
Biological Indices for Assessing Coral Reefs: UV Impacts – Dr. Richard Zepp, NERL, ORD, EPA
Mr. William Swietlik, OST, OW, EPA
Development of a Coral Reef Index of Biotic Integrity – Dr. Stephen Jameson, Coral Seas Inc.

Break

10:30 AM - 12:00 PM

The Impacts of Urban Drainage Design on Aquatic Ecosystems in the United States

Moderator: Mr. Jamal Kadri, OW, EPA
The Impacts of Urban Design on Aquatic Ecosystems in the U.S. – Ms. Diane Regas, OWOW, OW, EPA, and Ms. Hye Yeong Kwan, Center for Watershed Protection

Lunch

1:30 PM - 3:00 PM

Innovative Monitoring Techniques

Indicators – Ms. Susan Jackson, OST, OW, EPA
Probability-Based Monitoring Design – Mr. Barry Burgan, OWOW, OW, EPA
Integration of Water Quality Data and Landscape Information – Ms. Denice Wardrup, EPA Region 4

Break

3:30 PM - 5:00 PM

Volunteer Monitoring – Ten Years of Progress

Moderator: Mr. Joe Hall, OWOW, OW, EPA
Volunteer Monitoring: 10 Years of Progress, What's in the Future? – Ms. Alice Mayio, OWOW, OW, EPA
Volunteer Monitoring: A Coastal Perspective – Mr. Joe Hall, OWOW, OW, EPA
Volunteer Monitoring: Ten Years of Progress – Ms. Kathleen Kutschenreuter, OWOW, OW, EPA

Day 3 - Wednesday, May 7, 2003 (continued)

Homeland Security *(Pavilion Foyer)*

8:30 AM - 10:00 AM

Building Partnerships Towards Homeland Security

Moderator: Ms. Kathy Jones, CEPPO, EPA
Security: The Business of Chemistry's Action – Mr. Marty Durbin, American Chemistry Council
Homeland Security, Emergency Management, and a Water Utility – Mr. Paul Bennett, New York City DEP
A Public Utility Manager's View of Our World Post 9/11/2001 – Mr. Michael Marcotte, D.C. Water and Sewer Authority
Mr. Gordon Smith, Sandia National Laboratories
Ms. Janet Pawlukiewicz, WPTF, EPA
The EPA Safe Buildings Program – Dr. Nancy Adams, NHSRC, EPA

Break

10:30 AM - 12:00 PM

Building Partnerships Towards Homeland Security (continued) / BioWatch

Building Partnerships Towards Homeland Security (continued)
BioWatch – Nationwide Early Detection of Airborne Biological Agents – Mr. Thomas Coda, OAQPS, EPA

Lunch

1:30 PM - 3:00 PM

World Trade Center: Lessons Learned, and Personal Protection and Training

World Trade Center Lessons Learned and Interagency Collaboration – Moderator: Mr. Larry Reed, NIEHS
9/11 Lessons Learned for Worker Protection – Mr. Joseph Hughes, Jr., NIEHS and Mr. Bruce Lippy, National Clearinghouse for Worker Safety and Health Training
Immediate Response and Collaboration: EPA Region Perspective – Dr. Mark Maddaloni, EPA Region 2
Immediate Response and Collaboration: ATSDR Perspective – Mr. Sven Rodenbeck, ATSDR
Longer Term Response and Collaboration: NIEHS Perspective – Dr. Claudia Thompson, NIEHS
Evaluation of Health Effects of Clean Up and Recovery Workers at the World Trade Center Disaster Site – Dr. Alison Geyh, Johns Hopkins University

Day 3 - Wednesday, May 7, 2003 (continued)

Homeland Security (continued) *(Pavilion Foyer)*

Break

Preparing for Bioterrorism Threats in Water

3:30 PM - 5:00 PM

Overview and Introduction: Moderator: Dr. Jafrul Hasan, OST, OW, EPA
Welcoming Remarks – Mr. Chris Zarba, NCER, ORD, EPA
NHSRC's Water Security Research and Technical Support Program – Mr. Jonathan Herrmann, NHSRC, EPA
Ms. Grace Robiou, WPTF, EPA
Potential Technologies for Detection of Biological Threats in Water Supplies – Dr. John Ezzell, US Army Medical Research Institute of Infectious Diseases
"Early Warning Monitoring" and Sensor Technology Development – Ms. Janet Jensen, US Army Soldier and Biological Chemical Command
Dr. Alan Lindquist, NHSRC, EPA

List of Acronyms

ATSDR	Agency for Toxic Substances and Disease Registry
CDC	Centers for Disease Control
CEPPO	Chemical Emergency Preparedness and Prevention Office
DC	Dynamic Choropleth
DEP	Department of Environmental Protection
DNR	Department of Natural Resources
EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency
GED	Gulf Ecology Division
GLNPO	Great Lakes National Program Office
NCEA	National Center for Environmental Assessment
NEIC	National Enforcement Investigation Center
NERL	National Exposure Research Laboratory
NHEERL	National Health and Environmental Effects Research Laboratory
NHSRC	National Homeland Security Research Center
NIEHS	National Institute for Environmental Health Sciences
NIOSH	National Institute for Occupational Safety and Health
NOAA	National Oceanic and Atmospheric Administration
NRMRL	National Risk Management Research Laboratory
NSF	National Science Foundation
OAQPS	Office of Air Quality Planning and Standards
OAR	Office of Air and Radiation
OEI	Office of Environmental Information
OPEI	Office of Policy, Economics, and Innovation
OPP	Office of Pesticide Programs
OPPTS	Office of Prevention, Pesticides, and Toxic Substances
ORD	Office of Research and Development
OSCP	Office of Science, Coordination and Policy
OST	Office of Science and Technology
OSWER	Office of Solid Waste and Emergency Response
OW	Office of Water
OWOW	Office of Wetlands, Oceans, and Watersheds
PIPs	Plant Incorporated Protectants
R&D	Research & Development
REMAP	Regional Environmental Monitoring and Assessment Program
ReVA	Regional Vulnerability Assessment
SCCWRP	Southern California Coastal Water Research Project
SEQL	Sustainable Environment for Quality of Life
TBA	To Be Announced
TIO	Technology Innovation Office
UC	University of California
UMDNJ	University of Medicine & Dentistry of New Jersey
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WPTF	Water Protection Task Force